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Editorial Preface

From the Desk of Managing Editor…

Artificial Intelligence is hardly a new idea. Human likenesses, with the ability to act as human, dates back to Geek mythology with Pygmalion's ivory statue or the bronze robot of Hephaestus. However, with innovations in the technological world, AI is undergoing a renaissance that is giving way to new channels of creativity.

The study and pursuit of creating artificial intelligence is more than designing a system that can beat grand masters at chess or win endless rounds of Jeopardy!. Instead, the journey of discovery has more real-life applications than could be expected. While it may seem like it is out of a science fiction novel, work in the field of AI can be used to perfect face recognition software or be used to design a fully functioning neural network.

At the International Journal of Advanced Research in Artificial Intelligence, we strive to disseminate proposals for new ways of looking at problems related to AI. This includes being able to provide demonstrations of effectiveness in this field. We also look for papers that have real-life applications complete with descriptions of scenarios, solutions, and in-depth evaluations of the techniques being utilized.

Our mission is to be one of the most respected publications in the field and engage in the ubiquitous spread of knowledge with effectiveness to a wide audience. It is why all of articles are open access and available view at any time.

IJARAI strives to include articles of both research and innovative applications of AI from all over the world. It is our goal to bring together researchers, professors, and students to share ideas, problems, and solution relating to artificial intelligence and application with its convergence strategies. We would like to express our gratitude to all authors, whose research results have been published in our journal, as well as our referees for their in-depth evaluations.

We hope that this journal will inspire and educate. For those who may be enticed to submit papers, thank you for sharing your wisdom.

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CONTENTS

Effect of Sensitivity Improvement of Visible to NIR Digital Cameras on NDVI Measurements in Particular for Agricultural Field Monitoring

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***Abstract*—Effect of sensitivity improvement of Near Infrared: NIR digital cameras on Normalized Difference Vegetation Index: NDVI measurements in particular for agricultural field monitoring is clarified. Comparative study is conducted between sensitivity improved visible to near infrared camera of CuInGaSe: CIGS and the conventional camera. Signal to Noise: S/N ratio and sensitivity are evaluated with NIR camera data which are acquired in tea farm areas and rice paddy fields. From the experimental results, it is found that S/N ratio of the conventional digital camera with NIR wavelength coverage is better than CIGS utilized image sensor while the sensitivity of the CIGS image sensor is much superior to that of the conventional camera. Also, it is found that NDVI derived from the CIGS image sensor is much better than that from the conventional camera due to the fact that the sensitivity of the CIGS image sensor in red color wavelength region is much better than that of the conventional camera.**

Keywords—CuInGaSe; SiCMOS; NDVI; Rice crop; Tealeaves; S/N ratio; Sensivity

I. INTRODUCTION

Most of the commercially available digital cameras use Silicon utilized SiCMOS or CCD for the detector. The material of these detectors is silicon. Therefore, wavelength regions are limited up to around 900nm due to restriction of silicon image sensor of responsibility. Although these visible to 900nm wavelength region of digital cameras are acceptable for the general purposes, there are strong demands for acquisition of camera images with visible to near infrared region in particular for biometric security system, medical check system, agricultural and forestry application fields. In order to improve the sensitivity of the detector, CuInGaSe: CIGS image sensor is developed by Rohm Co., Ltd. in Japan [1]-[7]. The sensitivity of the image sensor covers from visible to 1200nm with the acceptable quantum efficiency.

One of application fields of the CIGS image sensor is vegetation monitoring. Importantly, vegetation monitoring needs wide wavelength coverage with an acceptable sensitivity. There are so many types of commercially available digital cameras. These, however, are not enough for monitoring of vegetation index which needs an acceptable sensitivity at red color wavelength and NIR wavelength regions. Usually, spectral reflectance of vegetation shows very low at the red color wavelength and quite high in the NIR region. Due to the fact that sensitivity of the commercially available digital cameras is not enough in NIR region while the reflectance of vegetations in red color wavelength is low, it would be better to improve the sensitivity of the digital camera in NIR wavelength region together with red color region. The CIGS image sensor gives one of solutions for solving the above mentioned problem.

Tea farm areas and rice paddy fields are selected for showing an effectiveness of the CIGS image sensor in particular for improving sensitivity in red to near infrared regions. The most important thing for tealeaves monitoring is NDVI estimation [8]-[20]. Amino acid contents containing in tealeaves depends on NDVI. Amino acid rich tealeaves taste good. Also, tealeaf growing stage monitoring needs fiber content estimation. Depending on growing stage, fiber content is getting large. Therefore, it is possible to estimate fiber content in tealeaves.

Meanwhile, protein content in rice crops is highly correlated with nitrogen content in rice leaves [21]-[26]. Protein content rich rice crops taste bad. Therefore, it is possible to estimated rice crop quality once protein content in rice crops is estimated. Nitrogen content in rice leaves depends on rice leaf reflectance. Therefore, it is capable to estimate protein content in rice crops through estimation of nitrogen content in rice leaves which is done with visible to near infrared camera data.

In order to estimate NDVI, leaf reflectance has to be measured in red and near infrared wavelength regions. The sensitivity of the CIGS image sensor in these wavelength regions is much better than those of the conventional digital cameras which utilized SiCMOS or CCD with silicon materials. Therefore, it is expected that NDVI estimation accuracy is improved. More than that, the sensitivity of the CIGS image sensor is better than that of the conventional digital cameras. This paper clarified these improvements quantitatively.

The next section describes the specification of the CIGS image sensor followed by the method and procedure of the experiments Then experimental results are described followed by conclusions with some discussions.

II. CIGS IMAGE SENSOR

A. *Specific Features of the CIGS Image Sensor*

One of the specific features of the CIGS image sensor is wide spectral coverage ranges from 430 to 1025nm with the sensitivity level (Quantum Efficiency) of 30. The wavelength coverage of the conventional SiCMOS image sensor ranges from 400 to 750nm. Fig.1 shows wavelength coverage of the CIGS image sensor and the conventional SiCMOS image sensor while Fig.2 shows outlook of the CIGS image sensor.

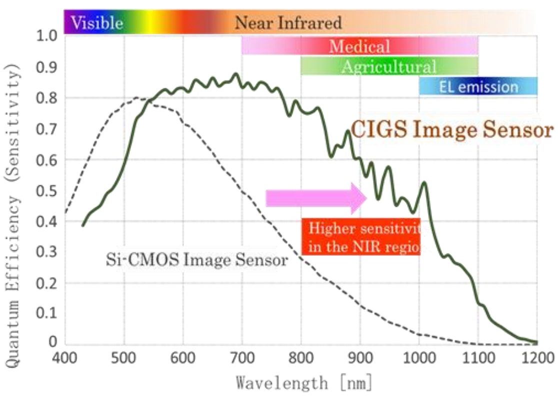


Fig. 1. Wavelength coverage of the CIGS and the conventional SICMOS image sensors

Fig.3 shows structural difference between the CIGS image sensor and the conventional SICMOS sensor. In particular, detector surface reflectance of the CIGS image sensor is much lower than that of the conventional SiCMOS image sensor. Also, aperture ratio of the CIGS image sensor is much higher than that of the conventional SiCMOS image sensor which results in high sensitivity in visible to near infrared wavelength regions.

Fig. 2. Outlook of the CIGS image sensor

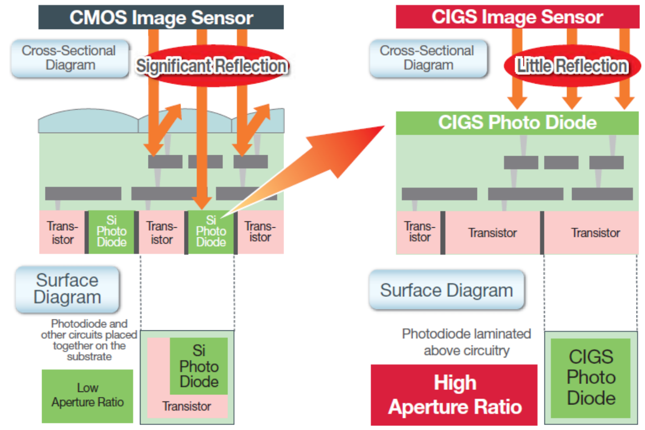
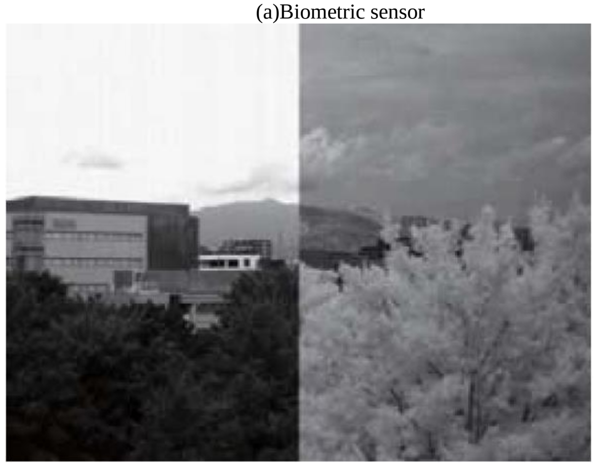


Fig. 3. Structural difference between the CIGS image sensor and the conventional SICMOS sensor

B. *Specific Applications of the CIGS Image Sensor*

Fig.4 (a) and (b) shows examples of applications of the CIGS image sensor for biometric sensors and for vegetation monitoring, respectively. Vein patterns of human hands can be detected by the CIGS image sensor as a biometric sensor for identification of the registered persons for security reason. On the other hand, vegetation monitoring can be done with the CIGS image sensor as shown in Fig.4 (b) because the reflectance of vegetation is very high in near infrared wavelength region.

(a)Biometric sensor



(b)Vegetation

Fig. 4. Examples of the CIGS image sensor

Fig.4 (b) left shows the outdoor scenery of vegetation acquired by CIGS image sensor without any filter while Fig.4 (b) right shows that with visible wavelength coverage cut filter. It is quite obvious that vegetated areas are brighter for the CIGS image sensor image than those areas for the CIGS image sensor with visible wavelength coverage cut filter image (NIR image).

III. EXPERIMENTS

A. Method and Procedure

Signal to Noise ratio: S/N ratio is evaluated by assuming the mean of the small portion of the acquired image where is seemed to be homogeneous pixel values must be the signal and by assuming the standard deviation of the same area of image is the noise. On the other hand, sensitivity can be evaluated by taking ratio between mean values of the different homogeneous portions of images.

Comparisons of S/N ratio and sensitivity are carried out between the CIGS image sensor and the conventional SiCMOS image sensor of Canon S100 with the replaced NIR filter to the originally blue filter. Spectral response of the S100 camera used is shown in Fig.5.

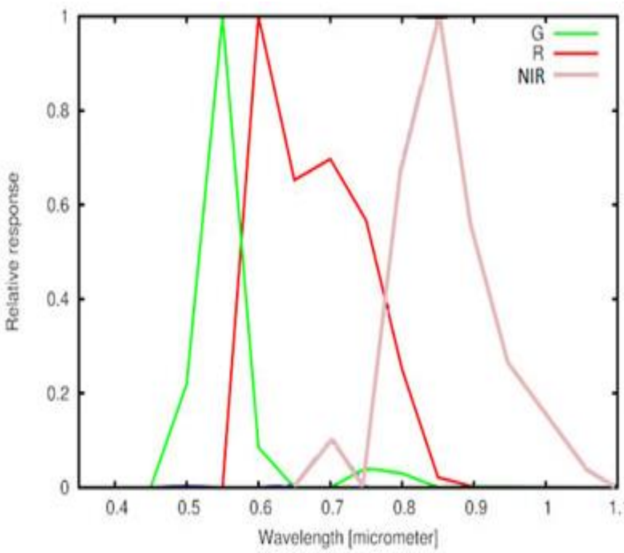
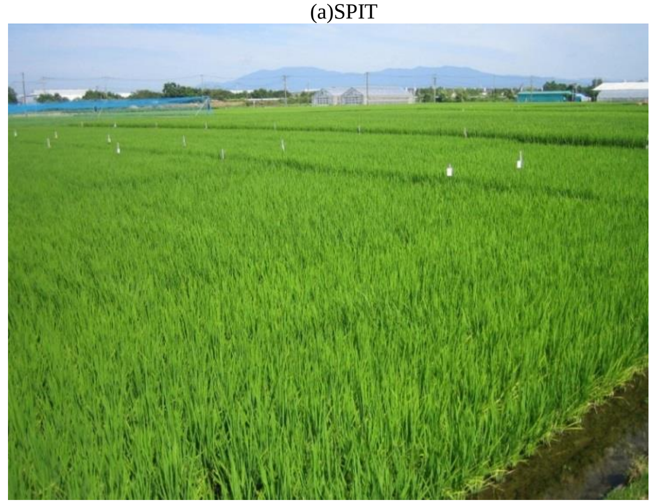


Fig. 5. Spectral Response of S100 Camera of which Blue Filter is Changed to NIR filter

B. Intensive Study Araeas

The experiments are conducted at the tea farm areas of the Saga Prefectural Institute of Tea: SPIT which is situated in Ureshino city, Saga Japan and the Saga Prefectural Institute of Agriculture: SPIA which is situated in Saga city, Saga Japan. Outlooks of SPIT and SPIA are shown in Fig.6 (a) and (b), respectively. The third tea farm field at the North tea farm areas of Yabukita Tea at SPIT is selected as tealeaf example while Hiyokumochi of sticky rice paddy field is also chosen as rice leaves example.

(a)SPIT



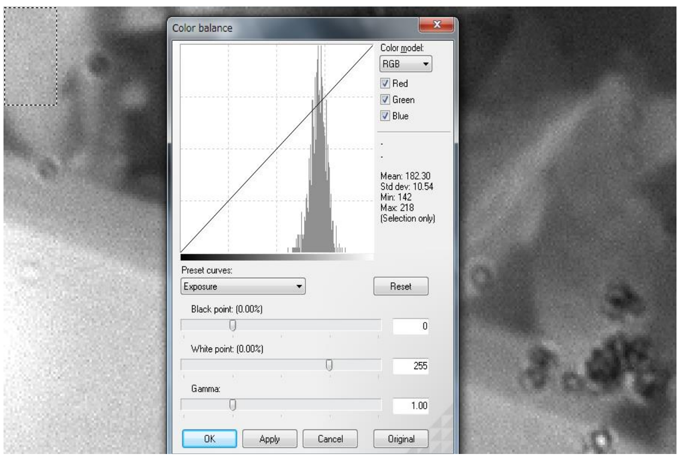
(b)SPIA

Fig. 6. Outlooks of the SPIT and SPIA

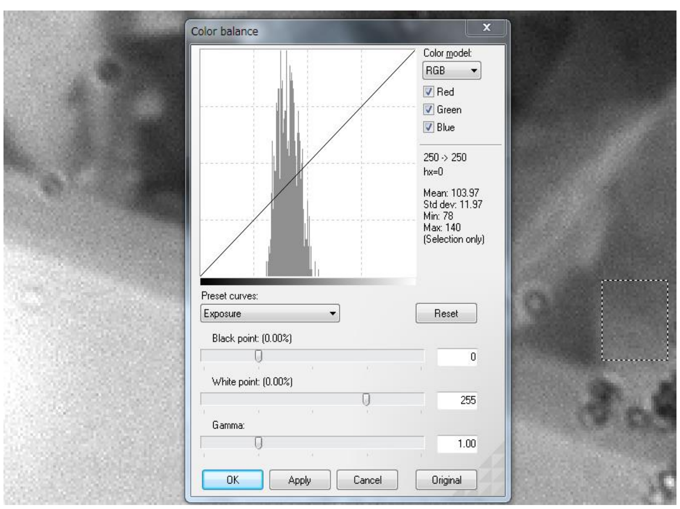
C. S/N Ratio and Sensitivity Evaluations

Fig.7 (a) shows top view of the acquired image of a small portion of the Yabukita Tea field on October 4 2015. Meanwhile, Fig.7 (b) shows the acquired image with the CIGS image sensor of the tiny portion of a piece of tealeaf together with histogram of the rectangle area of the tiny portion (m1 and s1 denotes the mean and the standard deviation of this portion of image, respectively) while Fig.7 (c) shows that of the different rectangle portion of the tiny portion (m2 and s2 denotes the mean and the standard deviation of this portion of image, respectively). On the other hand, Fig.7 (d) shows the acquired image with the S100 camera of the almost same portion of the tealeaf (m3 and s3 denotes the mean and the standard deviation of this portion of image, respectively) while Fig.7 (e) shows that of the different portion of the tealeaf on October 7 2015 (m4 and s4 denotes the mean and the standard deviation of this portion of image, respectively). All these images are acquired by the CIGS image sensor and the S100 image sensor with NIR filter.

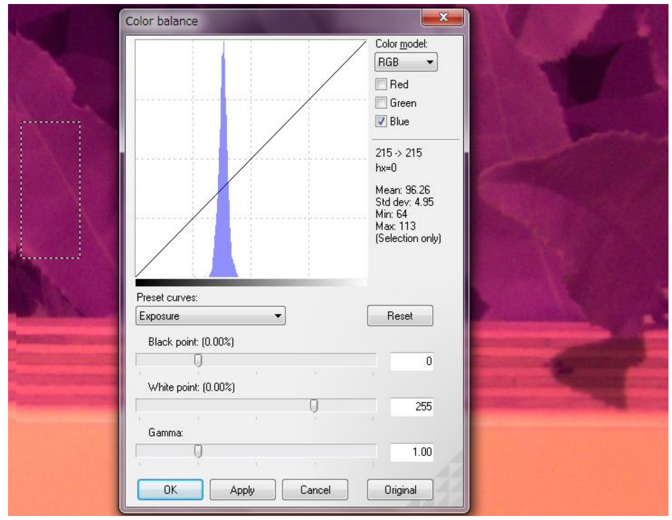
(a)Top view of Yabukita tealeaf



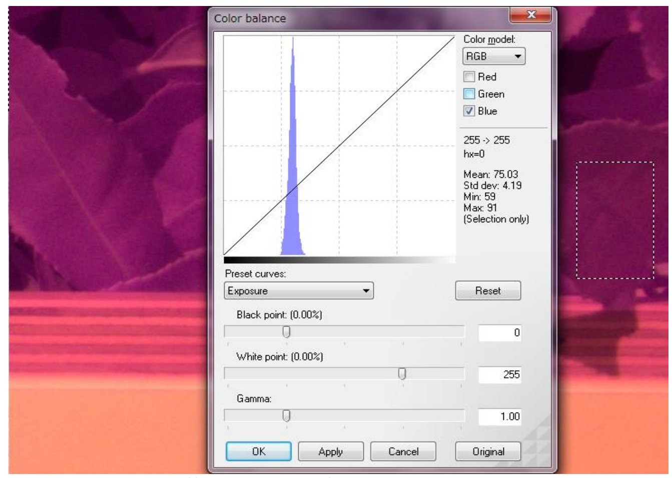
(b)Tiny portion of image with CIGS camera



(c)Different portion of image with CIGS camera



(d)Tiny portion of image with S100 camera

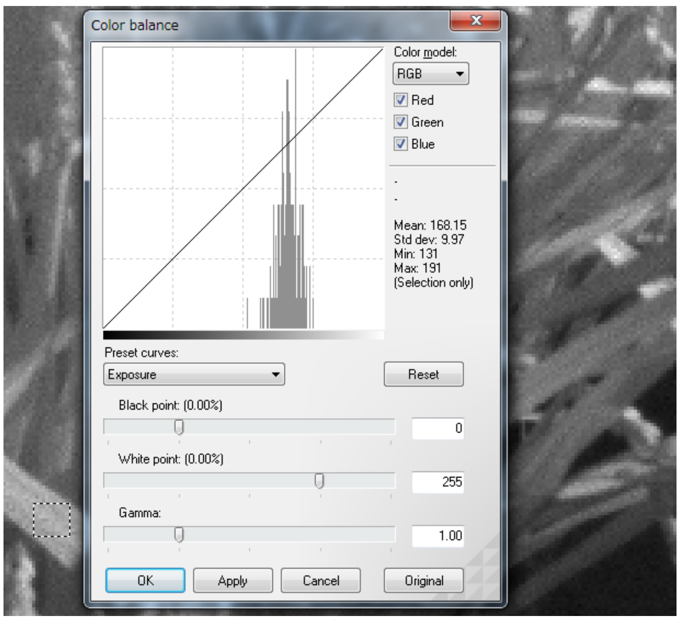


(e)Different portion of image with S100 camera

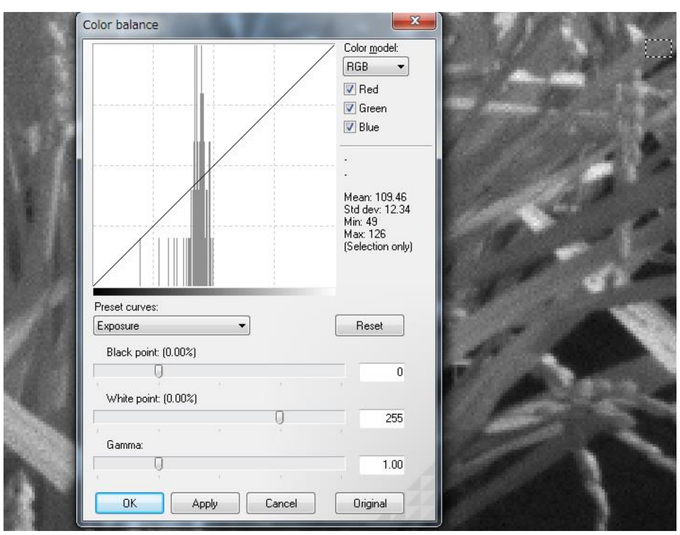
Fig. 7. Acquired images of Yabukita tealeaves with CIGS and S100 cameras

Fig.8 (a) shows slant view of the acquired image of a small portion of the Hiyokumochi rice paddy field. Meanwhile, Fig.8 (b) shows the acquired image with the CIGS image sensor of the tiny portion of a piece of rice leaf together with histogram of the rectangle area of the tiny portion (M1 and S1 denotes the mean and the standard deviation of this portion of image, respectively) while Fig.8 (c) shows that of the different rectangle portion of the tiny portion (M2 and S2 denotes the mean and the standard deviation of this portion of image, respectively). On the other hand, Fig.8 (d) shows the acquired image with the S100 camera of the almost same portion of the rice leaf (M3 and S3 denotes the mean and the standard deviation of this portion of image, respectively) while Fig.8 (e) shows that of the different portion of the rice leaf (M4 and S4 denotes the mean and the standard deviation of this portion of image, respectively).

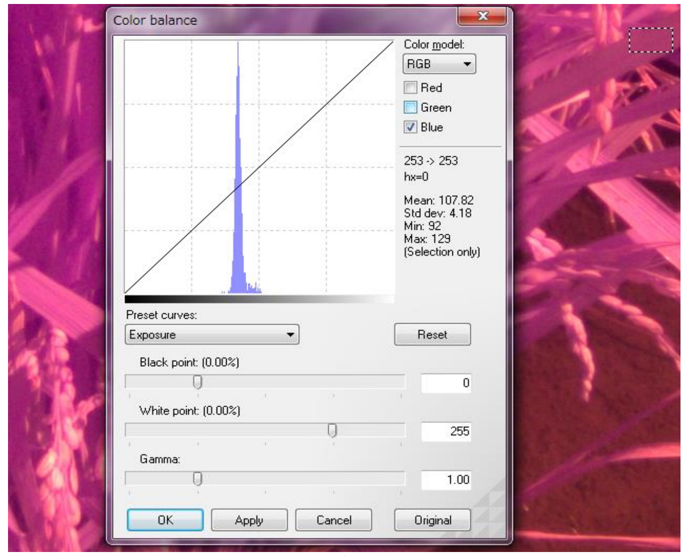
(a)Slant view



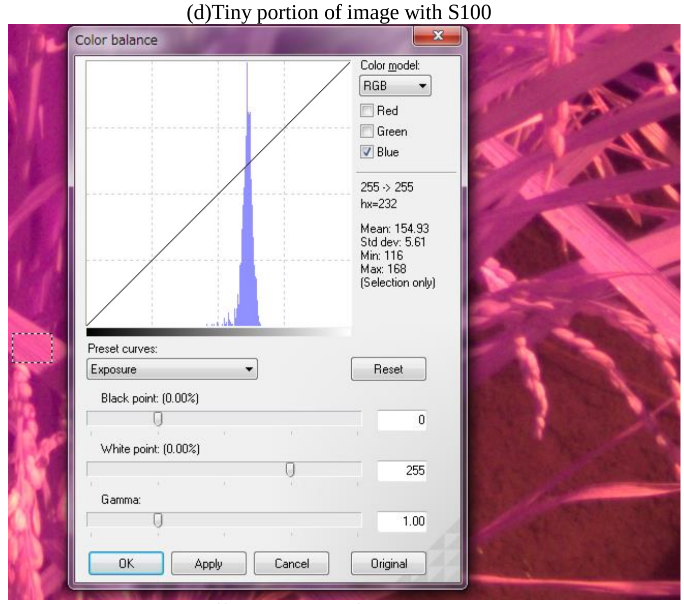
(b)Tiny portion of image with CIGS



(c)Different portion of image with CIGS



(d)Tiny portion of image with S100



(e)Different portion of image with S100

Fig. 8. Acquired images of Hiyokumochi rice leaves with CIGS and S100 cameras

From these mean values and standard deviations, the normalized sensitivities and the normalized S/N ratios can be calculated as follows,

a) Yabukita tealeaf

CIGS: Normalized Sensitivity:m1/m2=182.3/103.97=1.753 Normalized S/N=m1/s1=182.3/10.54=17.296(24.76dB), m2/s2=103.97/11.97=8.686(18.78dB)

S100: Normalized Sensitivity:m3/m4=96.26/75.03=1.283 Normalized S/N=m3/s3=96.26/4.55=20.277(26.14dB), m4/s4=75.03/4.19=17.907(25.06dB)

b) Hiyokumochi rice leaf

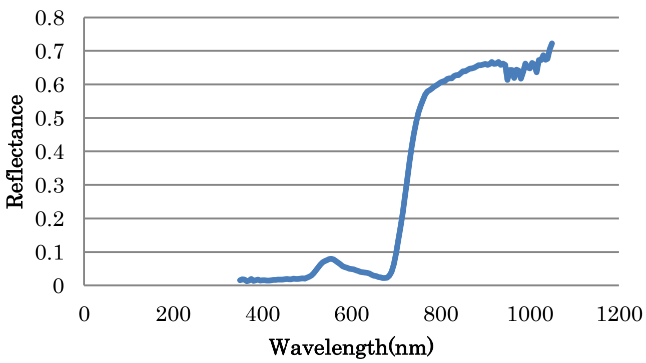
CIGS: Normalized Sensitivity:M1/M2=168.15/109.46=1.536 Normalized S/N:M1/S1=168.15/9.97=16.866(24.54dB), M2/S2=109.46/12.34=8.87(18.96dB)

S100: Normalized Sensitivity:M3/M4=154.93/107.82=1.437 Normalized S/N:M3/S3=154.93/5.61=27.617(28.82dB), M4/S4=107.82/4.18=25.794(28.23dB)

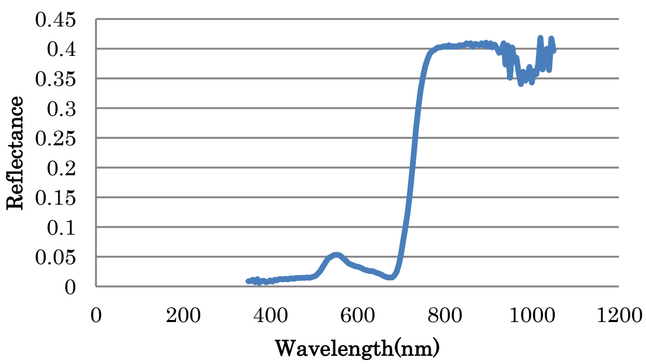
As the results, it may say that sensitivity of the CIGS image sensor is 10 to 50 % better than that of the S100 image sensor while S/N ratio of the S100 image sensor is 50 to 100 % better than that of the CIGS image sensor.

D. NDVI Estimation Accuracy Evaluations

Measured spectral reflectance of Yabukita tealeaves and Hiyokumochi rice leaves on October 4 and 7 are shown in Fig.9 (a) and (b), respectively.



(a)Yabukita Tealeaves



(b)Hiyokumochi Rice Leaves

Fig. 9. Spectral reflectance of the Yabukita tealeaves and Hiyokumochi rice leaves

From the spectral reflectance and the measured S/N ratios, it is capable to predict NDVI estimation accuracy improvement by the improvement of S/N ratio as shown in Table 1. From the S/N ratio, it becomes available to calculate noise level. By considering the calculated noise, NDVI estimation accuracy can be evaluated as shown in Table 1.

In these cases, plus minus 10% of noise levels for each red and NIR wavelength regions are added in the NDVI equation. Then as shown in Table 1, -9 to 8 % of NDVI is deviated from the NDVI without 10% of noise for tealeaves while -2 to 2 % of NDVI is deviated from the NDVI without 10% of noise for rice leaves (red colored values show improvement of NDVI calculations due to 10% improvement of S/N of the CIGS image sensor in comparison to the S100 image sensor.

TABLE I. IMPROVEMENT OF NDVI ESTIMATION ACCURACY BY IMPROVEMENT OF S/N RATIO

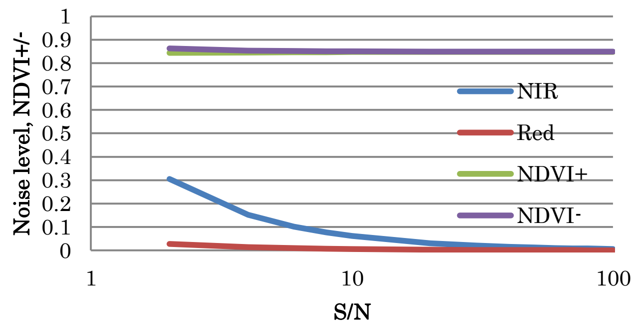
Tealeaf	Reflectance	S/N(dB)	Noise	NDVI+	NDVI-
870nm	0.61	24.28	0.0373	0.8485	
600nm	0.05	25.04	0.0028	0.8492	0.8477
Rice leaf				0.07988	-0.0903
870nm	0.4	31.95	0.0101	0.9048	
600nm	0.02	32.58	0.00047	0.9049	0.90456
				0.01713	-0.01802

Quantum efficiency in red wavelength is 0.75 for the S100 image sensor while that for the CIGS image sensor is 0.81. On the other hand, quantum efficiency in NIR (870nm) is 0.19 for the S100 image sensor while that of the CIGS image sensor is 0.63. Therefore, S/N influence of quantum efficiency difference on NDVI calculation is as follows,

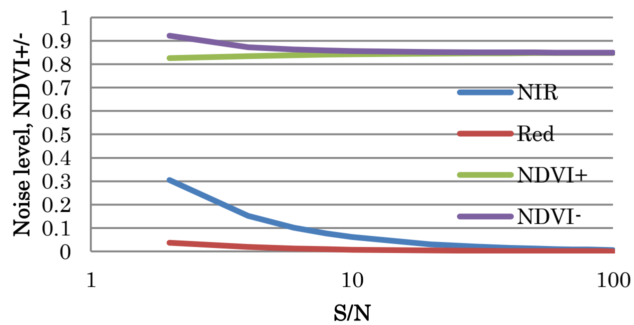
$$\text{(CIGS)}: (N\pm 1/0.19 - R\pm 1/0.75)/ (N\pm 1/0.19 + R\pm 1/0.75) \quad (1)$$

$$\text{(S100)}: (N\pm 1/0.63 - R\pm 0.81)/(N\pm 1/0.63 + R\pm 1/0.81) \quad (2)$$

where N and R denotes the signal level in NIR and red wavelength regions, respectively. Fig.10 shows the calculation results. When S/N ratio at red wavelength region is improved by 10%, NDVI is not so changed and improved.



(a)10% improvement



(b)50% improvement

Fig. 10. Noise level and NDVI improvement for the cases that S/N ratio at red wavelength region is improved by 10 and 50 %

Meanwhile, when S/N ratio at red wavelength region is improved by 50%, then NDVI is improved by 10%. More than that, quantum efficiency of the CIGS image sensor is 7 times and twice much higher than those of S100 image sensor in

NIR and red wavelength regions, respectively. Therefore, it is expected that estimated NDVI is 10 to 50 % accurate.

IV. CONCLUSION

Effect of sensitivity improvement of Near Infrared: NIR digital cameras on Normalized Difference Vegetation Index: NDVI measurements in particular for agricultural field monitoring is clarified. Comparative study is conducted between sensitivity improved visible to near infrared camera of CuInGaSe: CIGS and the conventional camera.

Signal to Noise: S/N ratio and sensitivity are evaluated with NIR camera data which are acquired in tea farm areas and rice paddy fields. From the experimental results, it is found that S/N ratio of the conventional digital camera with NIR wavelength coverage is better than CIGS utilized image sensor while the sensitivity of the CIGS image sensor is much superior to that of the conventional camera. Also, it is found that NDVI derived from the CIGS image sensor is much better than that from the conventional camera due to the fact that the sensitivity of the CIGS image sensor in red color wavelength region is much better than that of the conventional camera.

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An Implementation of Outpatient Online Registration Information System of Mutiara Bunda Hospital

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***Abstract*—Outpatient care is one of the medical services in Mutiara Bunda hospital. The management of outpatient registration of Mutiara Bunda Hospital used conventional way. Within 1 hour serving, 5 patients were enrolled with an average time of 13 minutes per patient. This caused the registration queue to get outpatient services. The study was conducted with the aim to produce outpatient online registration information system design of Mutiara Bunda Hospital in order to increase outpatient registration service and to manage data in getting medical care.**

The patients register on Outpatient Online Registration Information System without having to come first to the hospital and get a queue number, so they can estimate the waiting time in the hospital to get medical care at Mutiara Bunda Hospital; while the patients who come to the hospital are served directly by the registrar.

From the results of the research, it can be concluded that the application of Outpatient Online Registration Information System help in managing and processing data of patient registration to be able to get medical care immediately at Mutiara Bunda Hospital.

Keywords—Online Registration; Outpatient; Information System

I. INTRODUCTION

Mutiara Bunda Hospital is a private hospital which provides medical services to the community including a Home Care Unit, Emergency Room (ER), Inpatient, Outpatient, Clinical Laboratory, Pharmacy, and Medical Check Up. In 2015, the outpatient service consists of four polyclinics: General polyclinic has 8 doctors, Obstetrics and Gynecology polyclinic has 3 doctors, Medical and Aesthetic Acupuncture polyclinic has one doctor and Psychology polyclinic has 2 doctors.

In managing outpatient registration, Mutiara Bunda Hospital used conventional way in which patients came directly and patient data is recorded on a sheet of paper. This caused the registration queue in getting outpatient medical care.

The study was conducted with the aim to produce outpatient online registration information system design in Mutiara Bunda Hospital in order to increase outpatient registration service and to manage data in getting medical care.

II. THEORITICAL BASIS

A system is a network of interconnected procedures, cohere to perform an activity or to accomplish a particular goal (Jogiyanto HM, 2009).

An information system is a man-made system which provides an integrated set of manual components and computerized components in order to collect data, process data, and generate information for users (Sidarta, 1995).

A patient is a person who consults health problems to obtain the necessary health services either directly or indirectly to the doctor or dentist. Hospital Management Information System or HMIS is a communication information technology system which processes and integrates the entire workflow process of Hospital services in the form of coordination network, reporting and administrative procedures for obtaining information appropriately and accurately; and is part of the Health Information System (Permenkes No: 269, 2008).

Outpatient is a patient care for observation, diagnosis, treatment, medical rehabilitation and other health services without staying in the hospital (Menkes No: 560, 2003).

A good service quality must be provided by a service business. With the rise of new competitors will lead to intense competition in obtaining consumers as well as retaining customers. The observant consumers will naturally choose the good quality goods and services (Nova, 2010).

Hospital as a public service institution requires the existence of an information system which is accurate and reliable, and sufficient to improve services to patients as well as other relevant environment. With such a broad scope of services, of course, there are many complex problems which occur in the process of hospital services. The numbers of variables in the hospital determine the speed of the information flow needed by the users and the hospital environment (Handoyo etc, 2008).

According to Lidia Andriani (2009) in her research entitled Outpatient Registration Information System in Hospital by Using a Computer Program, by using Outpatient Registration Information System, the registration process of outpatients can be done easily and quickly; avoids double medical record numbers because this system can detect if there is any identical medical record numbers; facilitates registrar in printing medical cards, patients' identity and patient visit; provides information of daily and monthly reports quickly and the type of report may vary according to the needs; and saves time and energy of the patient registrars.

Dwi Parawanto (2012), in his research entitled Patient Administration and Registration Information Systems in SADEWA Mother and Child Hospital, generated Patient Administration and Registration Information Systems which processes data of patients, doctors, employees, examinations and administrations. The data then was considered as references for decision making by the doctors or the hospital, thus the services to patients would be improved.

According to Gunawan Susanto and Sukadi (2012), in their journal entitled Medical Record Information Systems On Regional Public Hospital (RPH) of Pacitan Web-Base Based, by developing a web-based medical record information system in RPH of Pacitan double medical records can be reduced and searching of medical record status can be done quickly, this overcame the medical record keeping system which has been used previously. The previous system stored the patients' medical records locally where the patients were examined and treated, this did not allow the direct data exchanging. This medical record information system helps medical personnel to carry out health services to patients.

Bambang Eka Purnama and Sri Hartati (2012), in their journal entitled Conveniences and Benefits of Patient Medical Database and Elasticity for Therapy Accessibility in Different Locations, explained that the Medical Record Information System which has been developed based on the standard among hospitals and clinics provides the benefits of conveniences and records of patient's medical history so that the number misdiagnosis and malpractices can be pressed.

Ahmad Anshari and Bambang E P (2013), in their journal entitled Distributed Data Patient In Medical Record Information System, with the Information system will be able to overcome the problem of data search quickly at a hospital. Patients who visit any hospital will feel comfortable and Mall practice would be suppressed because can easily find previous patient history data, so as to determine the subsequent diagnosis becomes easier.

III. SYSTEM ANALYSIS AND DESIGN

A. Problem Analysis

In the system of patient registration processing at Mutiara Bunda Hospital, there were several constraints in the processing and reporting of patient registration data. Based on interviews with registrar, revealed that the records of outpatients data used conventional way in which the data was written on sheets of paper in a large book. The number of patients in a doctor's practice schedule has been determined. Searching in the book caused the patients who came directly did not get queued at their desire. The long queues of patients caused the requirement of an online information system so the registration process will be faster and more efficient

B. System Design

a) Context Diagram

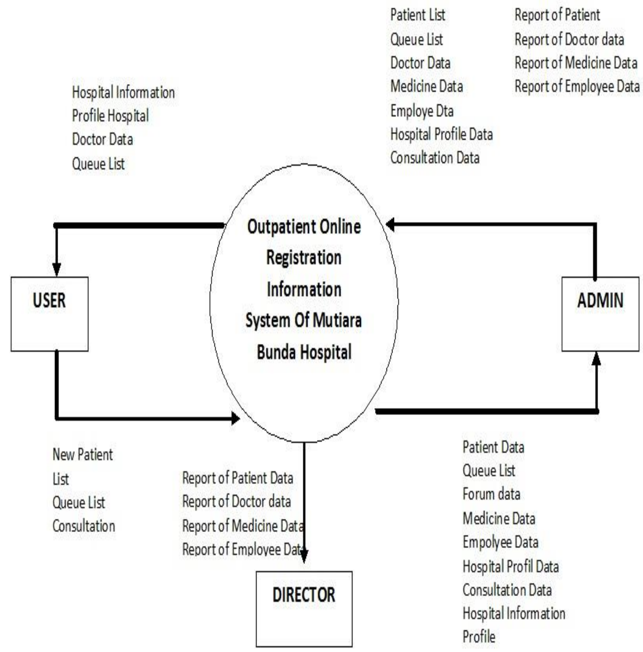

Fig. 1. Context Diagram

b) Use Case Diagram

Use Case diagram illustrates the common features of the Outpatient Online Registration Information System of Mutiara Bunda Hospital. To get into the system, the user must log in first.

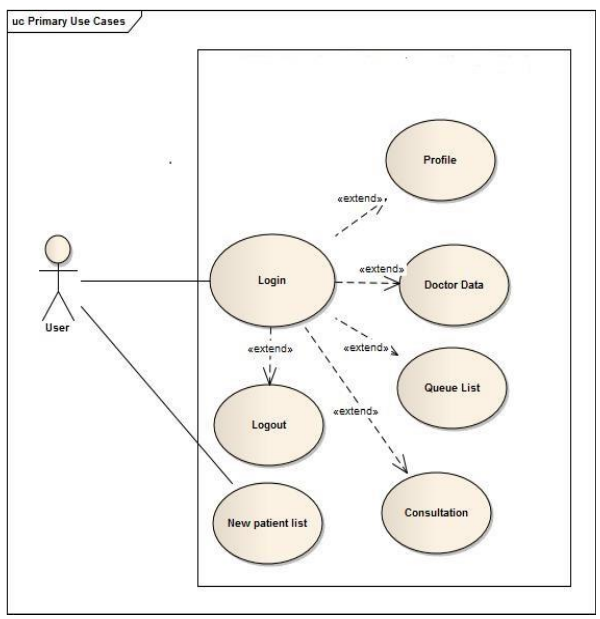

Fig. 2. Use Case of User

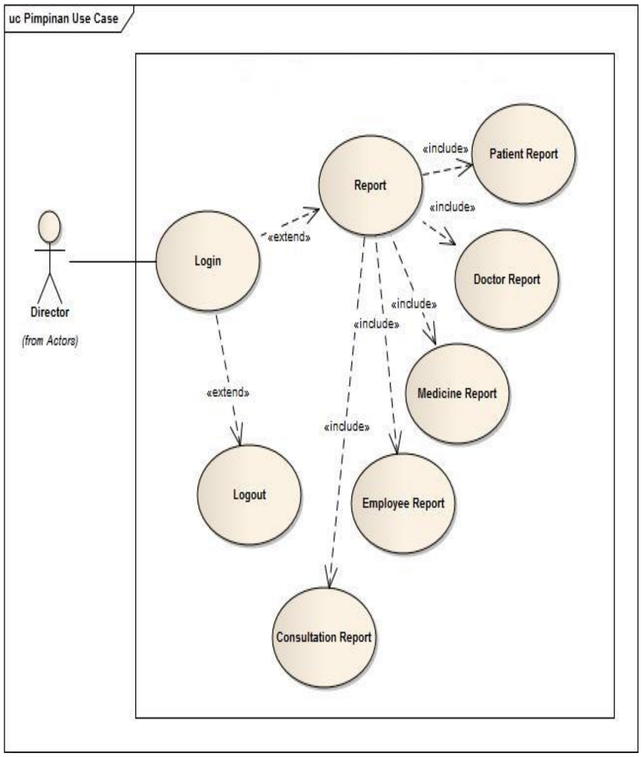

Fig. 3. Use Case of Director

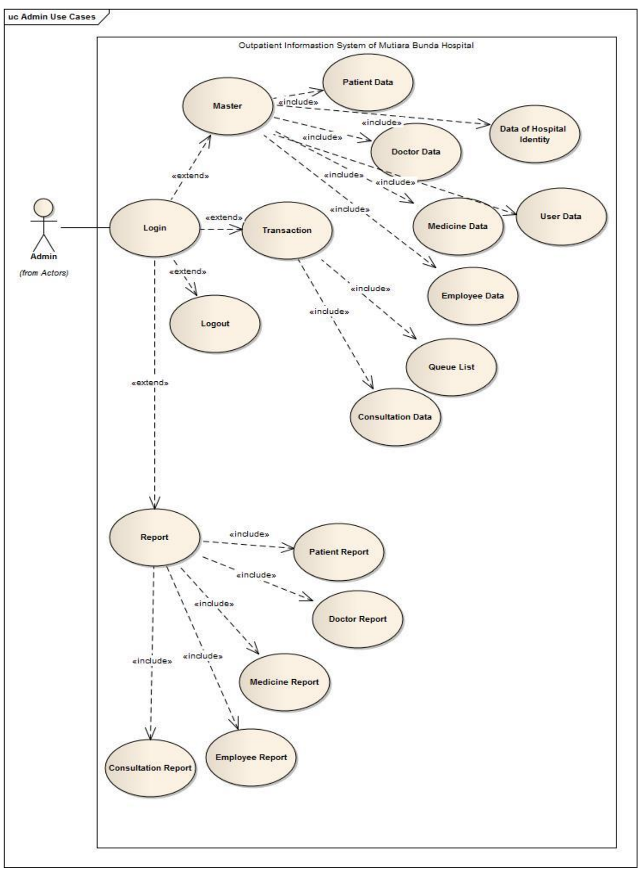

Fig. 4. Use Case of Admin

c) Activity Diagram

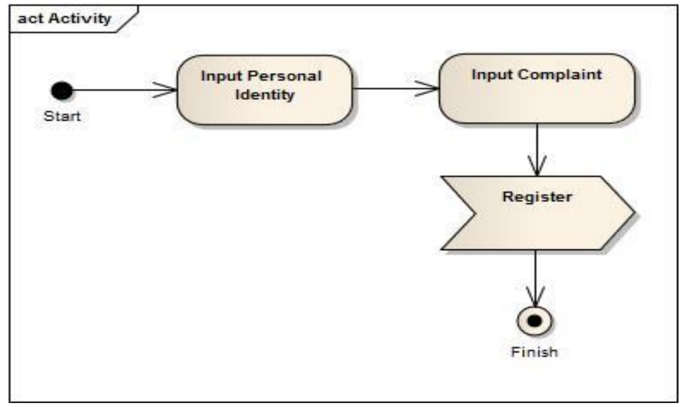

Fig. 5. Diagram Activity of Queue List

Fig 5. Activity diagram of queue list describes the process when the user enrolls for registration queue to get treatment or consultation with a doctor in Mutiara Bunda hospital.

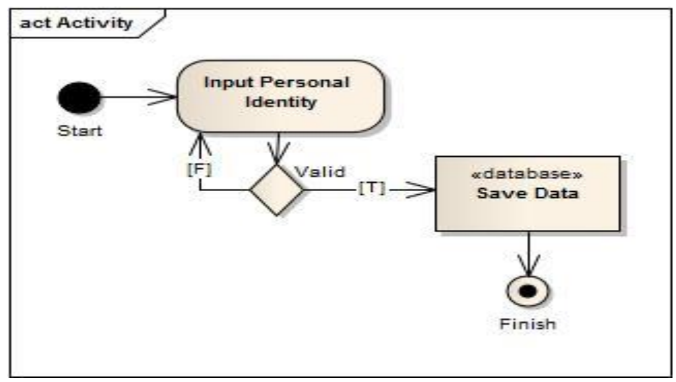

Fig. 6. Diagram Activity New of Patient List

Fig 6. Activity diagram of patient list illustrates the process of registering as new patients on Web page of Outpatient Online Registration Information System of Mutiara Bunda Hospital.

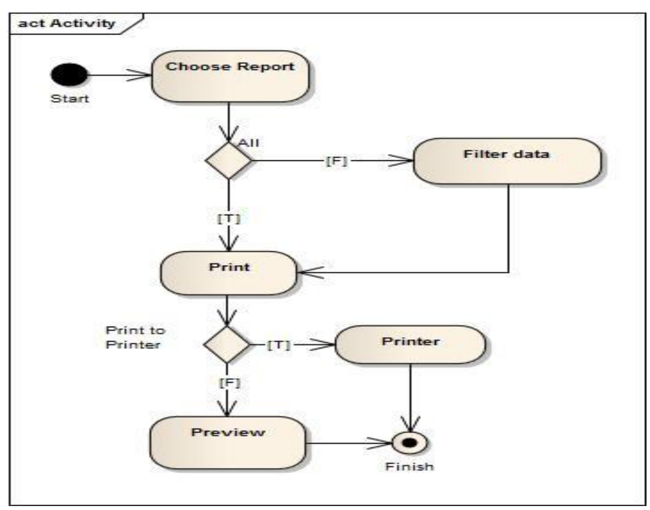

Fig. 7. Diagram Activity of Report

Fig 7. Activity diagram of report describes the activity processes of making a report to printing the report.

d) Sequence Diagram

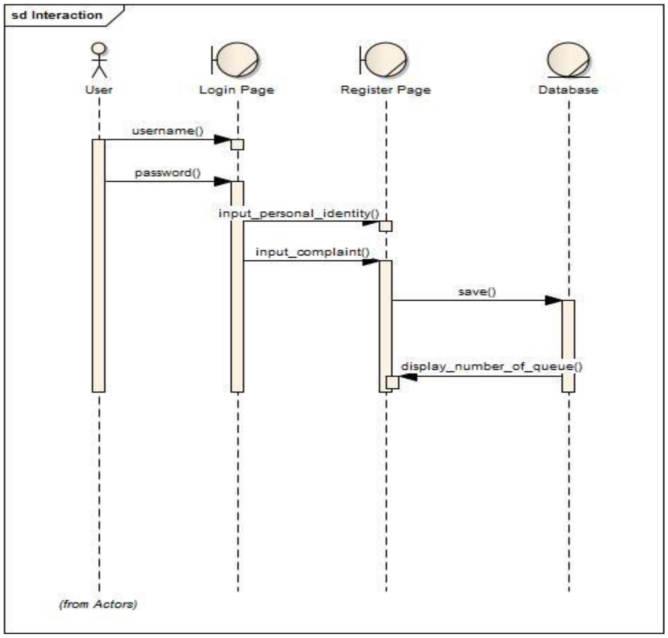

Fig. 8. Sequence Diagram of Queue List

Fig 8. Sequence Diagram of Queue list describe the process when the user enrolls for registration queue to get treatment or consultation with a doctor in Mutiara Bunda hospital.

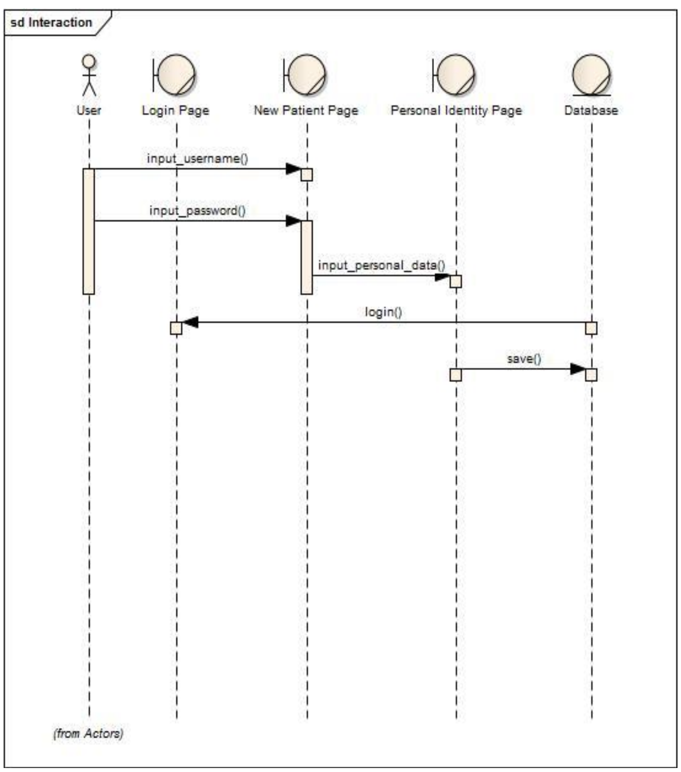

Fig. 9. Sequence Diagram of Patient List

Fig 9.Sequence diagram of Patient List illustrate the process of registering as a new patient on Outpatient Online Registration Information System Web page of Mutiara Bunda Hospital.

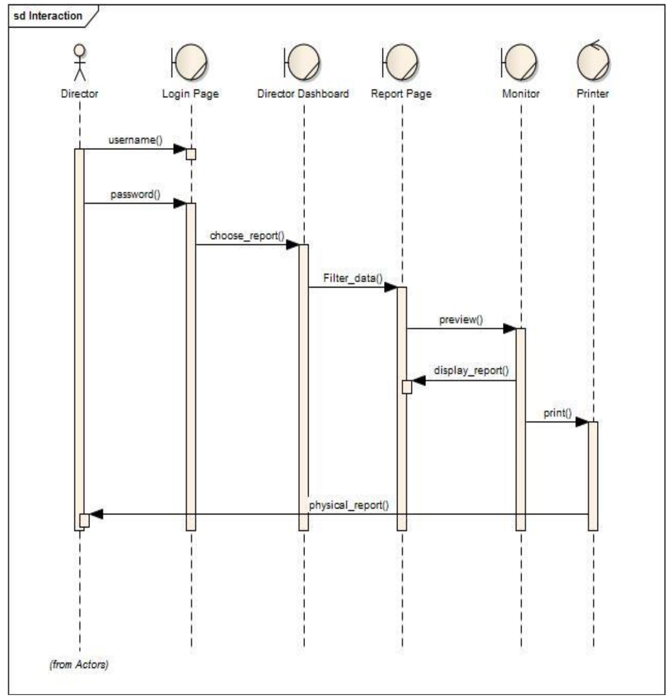

Fig. 10. Sequence Diagram of Report

Fig 10. Sequence Diagram of Report describes the activity processes of making to printing a report.

e) Database Model

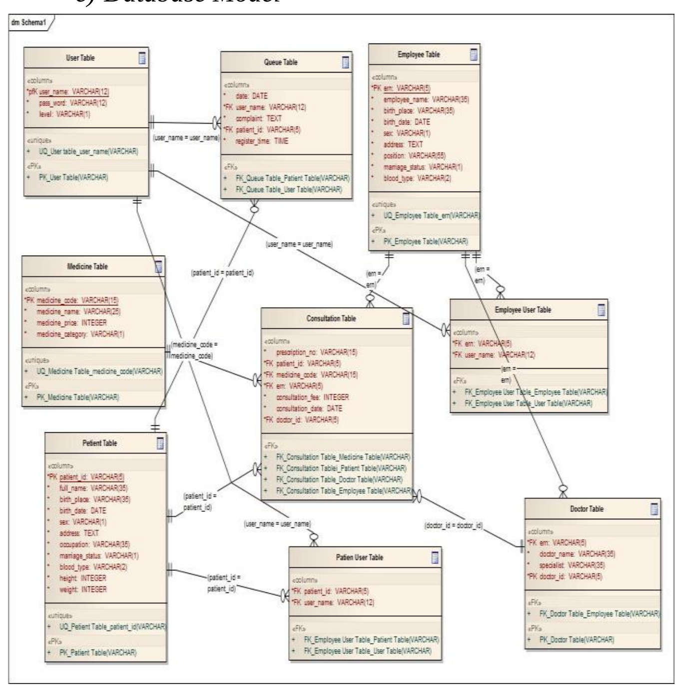

Fig. 11. Database Model

f) Database Design

TABLE I. TABLE USER

Field Name	Type	Information
user_name	varchar(12)	PRIMARY
pass_word	varchar(12)	-
Level	varchar(1)	Director, user & admin

TABLE II. TABLE QUEUE

Field Name	Type	Information
Date	Date	-
user_name	varchar(12)	FOREIGN
Complaint	Text	-
patient_id	varchar(5)	-
register_time	Time	-

TABLE III. TABLE EMPLOYEE

Field Name	Type	Information
ERN	varchar(5)	PRIMARY
employee_name	varchar(35)	-
birth_place	varchar(35)	-
birth_date	Date	-
sex	varchar(1)	-
address	Text	-
position	varchar(55)	-
marriage_status	varchar(1)	-
blood_type	varchar(2)	-

TABLE IV. TABLE MEDICINE

Field Name	Type	Information
medicine_code	varchar(15)	PRIMARY
medicine_name	varchar(25)	-
medicine_price	int(11)	-
medicine_category	varchar(1)	-

TABLE V. TABLE DOCTOR

Field Name	Type	Information
ERN	varchar(5)	FOREIGN
doctor_name	varchar(35)	Name
Specialist	varchar(35)	-
doctor_id	varchar(5)	PRIMARY

TABLE VI. CONSULTATION

Field Name	Type	Information
prescription_no	varchar(15)	-
patient_id	varchar(5)	FOREIGN
medicine_code	varchar(15)	FOREIGN
ERN	varchar(5)	FOREIGN
consultation_fee	int(11)	-
consultation_date	Date	-
doctor_id	varchar(5)	FOREIGN

TABLE VII. PATIENT USER

Field Name	Type	Information
patient_id	varchar(5)	FOREIGN
user_name	varchar(12)	FOREIGN

TABLE VIII. PATIENT

Field Name	Type	Information
patient_id	varchar(5)	PRIMARY
full_name	varchar(35)	-
birth_place	varchar(35)	-
birth_date	Date	-
Sex	varchar(1)	-
Address	Text	-
occupation	varchar(55)	-
marriage_status	varchar(1)	-
blood_type	varchar(2)	-
Height	int(11)	-
Weight	int(11)	-

TABLE IX. TABLE EMPLOYEE USER

Field Name	Type	Information
ERN	varchar(5)	FOREIGN
user_name	varchar(12)	FOREIGN

TABLE X. IDENTITY HOSPITAL

Field Name	Type	Information
hospital_name	varchar(35)	Hospital Name
phone_no.	varchar(15)	Phone Number
E-mail	varchar(35)	-
Address	Text	-
Owner	varchar(35)	-
license_no.	varchar(35)	Number of Licensing
Website	varchar(35)	Hospital Website

g) Interface Design

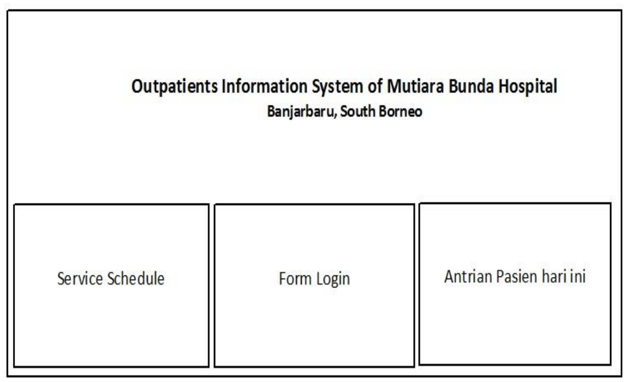

Fig. 12. Home Page

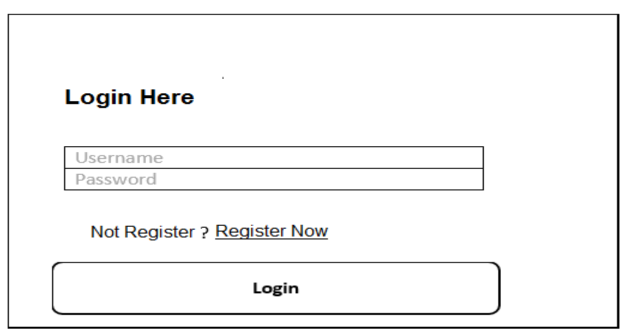

Fig. 13. Login Form

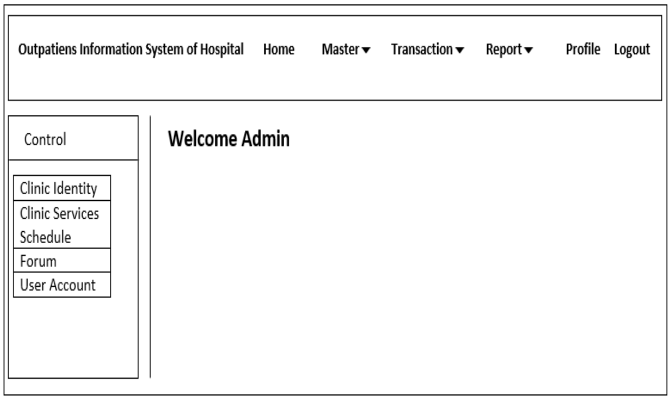

Fig. 14. Admin Dashboard

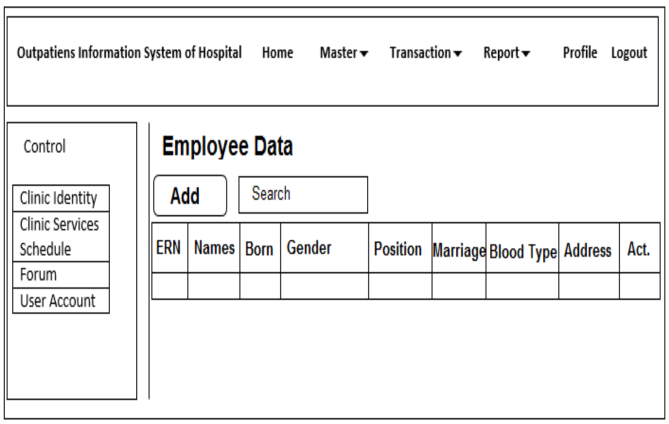

Fig. 15. Employee Dashboard

Fig. 16. Patient Registration Dashboard

IV. Implementation of the Systems

A. The Users of Outpatients Online Registration Information System

The users of outpatient online registration information system are administrator who is the holder of the highest privileges in the system, doctors, staff and patients.

B. Display Interface

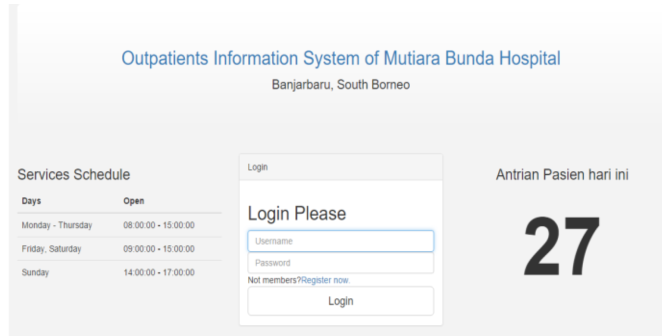

Fig. 17. Display of Homepage

Fig 17. Display of Homepage Outpatients Online Registration Information System has a main page which contains the login form used to authenticate the user in order to access the system, a link to the registration form (register now) used for user registration, and display of the service schedule and the number of queues.

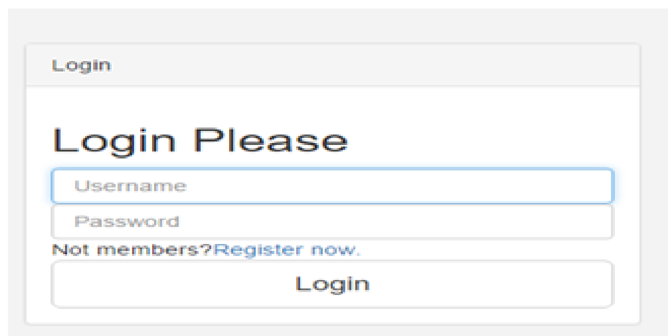

Fig. 18. Display of Form Login

Fig 18. Display the Login Form, user must enter a user name and password in order to access the Outpatients Online Registration Information System. If the user is a patient, then the user who has not been registered can register an account by clicking "Register now".

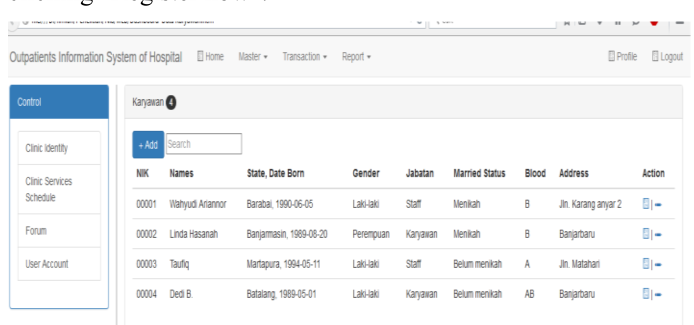

Fig. 19. Display of the Employee Data Page

Fig 19. Display the Employee Data Page, the user can control the data by adding, changing, or deleting the data of employees.

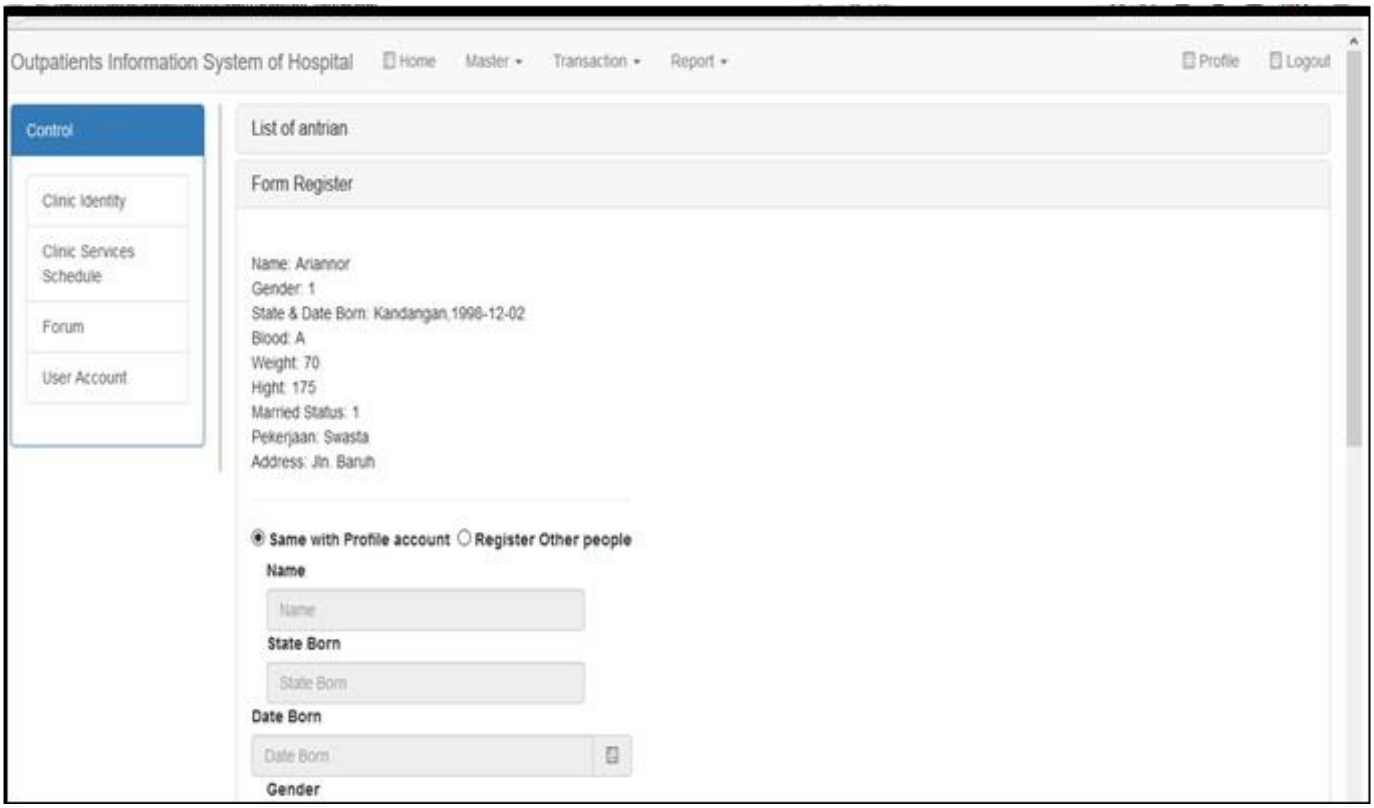

Fig. 20. Display of Outpatients Online Registration

Fig 20. Display of outpatients online registration, the patients who have filled the form on Outpatients Online Registration Information System will get queue numbers which can be be printed.

V. Conclusion

From the results of research, it can be concluded that:

1) The average time of outpatient registration in Mutiara Bunda Hospital conventionally per patient was 13 minutes which includes acceptance of patients, recording the patient's identity, storing data, and taking medical records of patients. Within 1 hour, only about 5 patients registration can be served.

2) On the Outpatients Online Registration System, the patients can register online without having to come to the hospital first, and they get queue numbers so they can estimate waiting time in the hospital to get medical care from Mutiara Bunda Hospital. While the patients who come directly to the hospital will received by the registrar.

3) After applying the Outpatient Online Registration Information System, number of patients served in 1 hour is approximately 12 patients. This means the application of Outpatient Online Registration Information System help to manage and process of patient registration data to be able to get medical care at Mutiara Bunda Hospital immediately.

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An Expert System-Based Evaluation of Civics Education as a Means of Character Education Based on Local Culture in the Universities in Buleleng

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***Abstract*—Civics education as a means of character education based on local culture has the mission to develop values and attitudes. In the educational process, various strategies and methods of value education can be used. In Civics Education characters are developed as the impact of education and also as its nurturing effect. Meanwhile, other subjects, which formally have the major mission other than character development have to develop activities that have the nurturing effect of character development in the students. However, in the educational process this has not run well. Hence, there is a need to evaluate educational programs at public as well as private universities in Buleleng regency. One of the evaluation techniques that can be used is the CIPP model combined with certainty factor method in expert system. The CIPP Model can evaluated the Civics education processes at all the public and private universities in Buleleng regency objectively, especially in probing local culture in character educational development. Meanwhile, the certainty factor method is used to determine the extent or degree of certainty of a component being evaluated in Civics educational processes.**

Keywords—Evaluation of Civics Education; Character; Local culture; Expert System; Certainty Factor

I. INTRODUCTION

Civics Education (PKn) has a very vital status and very strategic in fostering patriotism, nationalism and in nation and carácter building. However, in its implementation, it is very susceptible to practical political bias of the authority that tends to be an instrument used by the authority rather a means of the nation character building. The same thing occurs in developing countries as stated by Cogan (1998). He states: It (citizenship education) has also often reflected the interests of those in power in a particular society and thus has been a matter of indoctrination and the establishment of ideological hegemony rather than of education [1].

Various efforts have been done such discussion, conference, *sarasehan*, and other activities of that are like them that are vercommon all over the regions of Indonesia, a strong indicator that all of the components of the nation have a strong national commitment. However, there is a need for a comprehensive national policy, that is coherent, and sustainable that encourages the government to take an initiative to prioritize the nation character development. This implies that every effort of development has to always be directed to give a positive effect to the nation character development. In this modern world, as stated by Lickona (1991) we tend to forget the virtuous life, including in it self-oriented virtues or virtues to oneself, such as self control and moderation; and other-oriented virtues such a generosity and compassion or willingness to share and feel virtues[2].

As the consequence, the nation character building has a very wide scope and a multidimensional urgency level. Winataputra (2006) stresses that the nation character development has to be focused on three broad levels.,i.e., (1) to foster and strengthen the nation identity, (2) to keep the Unification of Republic of Indonesia (NKRI), and (3) to develop Indonesian man and womans and Indonesian community that have good ethics and a nation with dignity[3].

Civics Education as a means of character education based on local culture has the mission to develop values and attitudes. In the educational process it can use various strategies and value education methods. Civics Education develop character as the effect of the education and also as the dampak pengiring. Meanwhile, other subjects which formally have the major missions other than the character development, have to develop activities that have dampak pengiring of the development of character in the students. However, the education process has not run well.

For that reason, there is a need for evaluating the educational processes at the public and private universities in Buleleng regency. One of the techniques of evaluation that can be used is CIPP model combined with certainty factor in the expert system. The CIPP Model can evaluate the Civics Education process in all the public and private universities in Buleleng regency objectively, especially in probing the local culture in developing character education.

Meanwhile certainty factor method is used to determine the extent of certainty of one component which is being evaluated in the Civics Education process.

II. LITERATURE REVIEW

A. Evaluation

In [4], evaluation is a systematic collection of fact to determine whether in fact there is a change in students and establish the extent of change in the individual student.

In [5], Evaluation is an activity in collecting, analysing, and presenting information about an object of research and the results can be used to take a decision. In [6], Evaluation can be defined as the determination of conformity between the results achieved and the objectives to be achieved. In [7], Evaluation is an activity to gather information about the workings of something, which then the information is used to determine the appropriate alternative in making decisions.

From the opinions of the above can be concluded in general that the evaluation is an activity for data collecting, data analysing and data presenting into information about a particular object under study so that the results can be used to take a decision.

B. CIPP Model

In [8], the CIPP evaluation there are four components that must be passed is the evaluation of the component context, the evaluation of input component, the evaluation of process components, and the evaluation of product components.

In [9], CIPP model is a model in its activities through four stages of evaluation are: evaluation of the component context, input, process and product.

From the above opinions can be concluded in general that the CIPP model is a model that essentially has four stages of evaluation are: evaluation of the component context, component input, component process and component product.

C. Expert System

In [10], an expert system is considered as a computer simulation of human expertise. In [11], Expert System is a program that behaves like some experts, and have limited domains of application in certain problems.

In [12], an expert system is a computer program that stimulates an evaluation and behaviors of human or organization that has knowledge and experiences of experts in a certain field.

In [13], Expert system is an artificial intelligence system that combines the basics of knowledge and inferential motor in such a way that it can adopt the ability of an expert into the computer, so that the computer can solve problems such as those often done by experts.

In [14], Expert system is made only in certain knowledge domain to approximate human ability only in one field.

In [15], Expert system is a kind of contemporary software that makes computer more useful than before.

From the various opinion above it can be concluded that artificial intelligence that combines the basics of knowledge and inferential machine in order it can adopt the ability experts into an instrument to solve problems like what experts do.

D. Certainty Factor (CF)

Certainty Factor (CF) is one of the methods used to show the extent of certainty of facts or rules. 16]. The notation of certainty factor caused by one fact is as follows:

CF[H,E] = MB[H,E] – MD[H,E]………………………….1

In which:

CF[H,E] = certainty/ confidence factor about hypothesis H towards fact E (between -1 and 1)

MB[H,E] = the extent of confidence towars hypothesis H with fact E (between 0 and 1)

MB[H,E] = the extent of nonconfidence towards hypothesis H with fact E (between 0 and 1)

Meanwhile factor notation of certainty facts that are caused by more than one fact is as follows:

CF[H,E1^E2] = MB[H,E1^E2] – MD[H,E1^E2]………2

In which:

MB[H,E1^E2] = MB[H,E1]+MB[H,E2]*(1-MB[H,E1])

MD[H,E1^E2] = MD[H,E1]+MD[H,E2]*(1-MD[H,E1])

In which:

CF[H,E1^E2] = certainty/confidence factor about hypothesis H towards fact E1 and E2 (between -1 and 1)

MB[H,E1^E2] = the extent of confidence towards hypothesis H with facts E1 and E2 (between 0 and 1)

MB[H,E1^E2] = the extent of nonconfidence towards hypothesis H with facts E1 and E2 (between 0 and 1)

III. METHODOLOGY

A. Object dan Research Site

1) Research Object is Civics Education program as the means for character education.

2) Research Site at universities in Buleleng regencies.

B. Data Type

In this research, the authors use primary and secondary data, quantitative and qualitative data.

C. Data Collection Techniques

In this research, the authors use data collection techniques such as observation, interviews, and documentation.

D. Evaluation Model

Evaluation model used in this research is CIPP model and combined with the certainty factor method.

E. Aspect of Evaluation

The aspects that were evaluated in Civics Education can be seen in the table of evaluation criteria as follows.

TABLE I. EVALUATION CRITERIA

No	Component	Aspects
1.	Context	The status of Civics Education in university curriculums
		Visions and Missions of Civics Education
2.	Input	Description of Civics Education
		Human resources
		Infrastructures and facilities
3.	Process	Planning for Civics Education
		Implementation of Civics Education
		Assessment of Civics Education
4.	Product	Effect of the implementation of Civics Education
		Results expected from the implementation of Civics Education

IV. Result and Discussion

A. Result

1) Result of analysis from CIPP Model

The result of analysis using CIPP model can be explained as follows:

a) In the Context components: Civics Education at universities in Buleleng regency has followed the curriculum written in each respective institution.

b) In the Input components: Civics Education at universities in Buleleng regency has followed the descriptions offered by the Ministry of Research, Technology and Higher Education. The educational background of the lecturers of Civics Education at the universities in Buleleng regency is minimally Master degree in the Department of Pancasila and Civics Education Department.

c) In the Process components: The universities in Buleleng regency have appreciated, accommodated, and internalized local culture based character education through Civics Education that is stipulated in the curriculum. In the effort to internalize and transform character education in the educational process, the lecturers of Civics Education have used multi-approaches multi-strategies, and multi-methods. One of the dominant approaches practiced in education is contextual approach.

d) In the Product components: The realization of contextual approach is the probing of local wisdoms of Baliese community that can be used as the model in developing character education, which among other things include:

i. *Tri hita karana* ideology terminologically, the concept of *tri hita karana* comes from the word *tri* that means three;; *hita* prosperity, happiness; and *karana* that means source of cause. Thus *tri hita karana* means three sources of cause of the prosperity and happiness in life and the life of all creatures of God [17]. The prosperity of life can be realized if there is a harmony between human beings and the creator (God), human beings and their fellow human beings, and human beings and the natural environment. *Tri hita karana* then developed into the teaching of harmony, and balance and at the same time also the interdependence in a life system. This is based on the awareness that the universe is a complexity of elements which form a system of universe. The major principle of balance and harmony in the relationship between human beings and God, human beings and their fellow human beings, and human beings and the natural environment becomes the philosophy of life of the Balinese community, both in developing the system of knowledge, the patterns of behavior, attitudes, values, tradition, art, etc. This is very useful for Balinese community in the effort to meet the needs and solving problems of life that are faced both in interpersonal and intergroup relations. Since these major principles become the basis for the development of attitudes, values, behaviors, values, and social relationship in Balinese community, and these principles have been internalized and institutionalized in the social life of the Balinese social structure. At the individual level, Balinese as the microcosmic environment (*buana alit*), for example, it is believed that human life is a dynamic manifestation of relational motion of *atman* (spirit), *prana* (power, strength), and *sarira* (physical body element). The broader social institutions of the Balinese is the environment of the macrocosmic environment of the individual, from the family organization as the smallest social institution, group of kinship (clan), *desa pakraman*, *subak* organization, *seke teruna-teruni*, *seke manyi*, *seke gong*, up to the Balinese community as a whole, apply the same pattern in creating the harmony among the three elements above in developing a daily cultural activity by reinforcing the concepts of *parhyangan, pawongan, dan palemahan*[18]. Through the concept of *parahyangan*, Balinese man and woman and Balinese community believe that everything in this world including human beings come from and because of this will come to God. This awareness encourages Balinese man and woman and Balinese community to improve their *crada dan bhakti* (belief and devotion) to God *(Ida Sang Hyang Widhi Waca)* in accordance with the teachings of the religion, beliefs and traditions that they practice in life. It is not surprising since at each level of the Balinese social institution are erected holy places of worshipping God the places that function as a means for human beings to relate themselves with God. It is also believed that all cultural products and human civilization and also Balinese community are created as offerings to God and spirits that are often called *yadnya*. We can see, for example, from the religiously symbolic meanings hidden and contained in the implementation of *yadnya*, the traditional or customary activities, and Balinese art and cultural works. Through the concept of *pawongan*, then, Balinese man and woman and Balinese community believe that naturally, human beings are equal as the creature and servants of God who are cultured and as a consequence, need to develop the attitude of *asah*, *asih, dan asuh* and work together to achieve the goal of human life, humans as social creature. The third element from the *tri hita karana* teaching is *palemahan*. Through this concept, Balinese man and Balinese community believe that there is a need for a harmonic relationship between human being and the other elements and powers of nature. Such relationship is symbolized with the expression "*kadi manik ring cecepu*" (like a baby in its mother's womb) [19]. Balinese man and woman are aware that human beings cannot be separated from the nature, since it is the nature that gives humans prosperity. Even they believe that the elements and power of this nature are the siblings of human beings as symbolized that every baby born it is always together with its four siblings (placenta, amniotic fluid, lamas/ placenta wrapping pembunga kus arib-ari and blood). The manifestation of love of Balinese man and woman towards these elements and powers of the universe is expressed in a sacrifice ceremony to *bhuta* (*butha yadnya*), in addition to actively maintaining and preserving the natural environment.

ii. The *tat twam asi* teaching which literally means “he or she is you too”. With the teaching of *tat twam asi* is meant that actually all human beings are one and the same creature of God. Thus, it is believed that to help other people means to help oneself, and to hurt others means to hurt oneself too [20]. Balinese man and woman believe and appreciate the differences in the characteristics of the life of human beings as the result of *rwabhineda* ties themselves.

iii. The concept of *Nyama braya*. *Nyama braya* is a concept that comes from the community cultural system. The cultural value system is the highest level and the most abstract of the customs. This is caused by the fact that the cultural values are concepts about what is life in the thinking of most of the people of a particular community about what they consider valuable, important and correct that have to be done in the life in this world, these high values are expected to function as a guide that gives a direction and orientation to the people of Bali, both those who live in complex towns or cities and those who live in villages and mountains with a simple life, there are some cultural values that are related with each other to form a system, and this system serves as a guideline from the ideal concepts in the culture as a strong motif for the direction in life of the community members. *Nyama braya* is the application of the concept of *rukun*. The word *rukun* contains the meanings close, peaceful, and do not fight with each other, thus it is likened to the life of a couple in a family that is *rukun*, it means harmonious and peaceful. The most essential meaning of *kerukunan hidup* is to protect harmony in the community that is multicultural by fostering the attitude of mutual respect and mutual complementing since to be aware that human beings are the best of all the creatures that God created. There is no absolutely perfect human being *(tan hana wong swasta nulus*). Human beings need the help from each other (*paras paros sarpanaya, salunglung sabhayantaka, saling asah, asih dan asuh*).

Differences/varieties are a must (*rwabhineda)*. The awareness in practicing the teaching of religion is tested when one is aware of life plurality (*tattwamasi)*. To show an attitude towards differences as human right of each individual (*sarva santhu niramayah)* as long as it does not violate the other’s right.

2) Result of Analysis of Certainty Factor Method

TABLE II. SCORE OF DETERMINING THE DEGREE OF CERTAINTY OF A COMPONENT EVALUATED IN CIVICS EDUCATION PROCESS

No	Respon-Dent	Component of Evaluation								CF Value	
		C (%)		I (%)		P (%)		P (%)		Dec	%
		B	U	B	U	B	U	B	U		
1	R1	90	10	98	2	95	5	98	2	0,82	82
2	R2	97	3	99	1	99	1	99	1	0,94	94
3	R3	95	5	95	5	95	5	99	1	0,80	80
4	R4	95	5	95	5	95	5	99	1	0,80	80
5	R5	97	3	99	1	99	1	99	1	0,94	94
6	R6	97	3	99	1	99	1	99	1	0,94	94
7	R7	95	5	95	5	95	5	99	1	0,80	80
8	R8	90	10	98	2	95	5	98	2	0,82	82
9	R9	97	3	99	1	99	1	99	1	0,94	94
10	R10	95	5	95	5	95	5	99	1	0,80	80
11	R11	97	3	99	1	99	1	99	1	0,94	94
12	R12	90	10	98	2	95	5	98	2	0,82	82
13	R13	97	3	99	1	99	1	99	1	0,94	94
14	R14	95	5	95	5	95	5	99	1	0,80	80
15	R15	95	5	95	5	95	5	99	1	0,80	80

Explanation:
B : The extent of belief/faith in component
U : The extent of disbelief/Unfaith in component
C : Context component
I : Input component
P : Process component
P : Product component

B. Discussion

1) Working Principle of Certainty Factor (CF)

The working principle of *certainty factor* (CF) is by doing a substraction between the extent of disbelief in hypothesis H with Fact E (MB[H,E]) and the extent of belief in hypothesis H with fact E (MD[H,E]). In addition, there is also the principle of *certainty factor* (CF) that is used to determine a hypothesis based on some evidence, i.e., by substracting the extent of disbelief in hypothesis H with facts E1 and E2 (MB [H, E1^E2]) terhadap the extent of belief in hypothesis H with facts E1 and E2 (MD [H,E1^E2]).

2) Certainty Factor (CF)Working Procedures

Referring to the result in table II above, for respondent RI then its Certainty Factor (CF) following the following procedures:

a) Determining Certainty Factor (CF) of the success of the context component caused by the aspect of Civics Education status in the curriculum of Higher Learning, and Vision and Missions of Civics Education Course

CF [H,E] = MB[H,E] – MD[H,E]
CF [H,E] = 0.9-0. 1 = 0. 8

b) Determining Certainty Factor (CF) of the success of the input component caused by the aspect of description of Civics Education, human resources, infrastructure and facilities

CF [H,E1^E2] = MB[H,E1^E2] - MD[H,E1^E2]
MB[H,E1^E2] = MB[H,E1]+MB[H,E2]*(1-MB[H,E1])
MB[H,E1^E2] = 0. 9+0. 98*(1-0. 9) = 0. 998
MD[H,E1^E2] = MD[H,E1] + MD[H,E2]*(1-MD[H,E1])
MD[H,E1^E2] = 0. 1+0.02*(1-0. 1) = 0. 118
CF [H,E1^E2] = 0. 998 – 0.118 = 0. 880

c) Determining Certainty Factor (CF) of the success of the process component caused by the aspect of planning of Civics Education, implementation of Civics Education and assessment of Civics Education

CF [H,E1^E2^E3] =MB[H,E1^E2^E3] – MD[H,E1^E2^E3]
MB[H,E1^E2^E3] =MB[H,E1^E2] + MB[H,E3]*(1-MB[H,E1^E2])
MB[H,E1^E2^E3] = 0.998+0.95*(1-0.998) = 0.999
MD[H,E1^E2^E3] = MD[H,E1^E2] + MD[H,E3]*(1-MD[H,E1^E2])
MD[H,E1^E2^E3] = 0.118+0.05*(1-0.118) = 0.162
CF [H,E1^E2^E3] = 0.999 – 0.162 = 0.837

d) Determining Certainty Factor (CF) of the success of the product component caused by the aspect of effect of implementation of Civics Education as the means of character education based on local culture, and the result expected from the implementation of Civics Education.

CF [H,E1^E2^E3^E4] = MB[H,E1^E2^E3^E4] – MD[H,E1^E2^E3^E4]
MB[H,E1^E2^E3^E4] = MB[H,E1^E2^E3] + MB[H,E4] * (1-MB[H,E1^E2^E3])
MB[H,E1^E2^E3^E4] = 0.999+0.98*(1-0.999) = 0.999
MD[H,E1^E2^E3^E4] = MD[H,E1^E2^E3] + MD[H,E4] * (1-MD[H,E1^E2^E3])
MD[H,E1^E2^E3^E4] = 0.162+0.02*(1-0.162) = 0.179
CF [H,E1^E2^E3^E4] = 0.999 – 0.179 = 0.82

From the calculation the value of CF for respondent RI to determine the degree of certainty of components evaluated in Civics Education process using CIPP is 0.82 or 82%.

Following the same steps of calculation above for data from other respondents produced results as shown in table above.

V. Conclusions

Based on the analysis that has been made and the results of the discussion in the previous section, then some conclusions can be drawn as follows:

a) Imperatively, institutes of higher learning are one of the places for character education that is developing the nation character. The character development in the institutes of higher learning also constitutes a pillar in the institute of higher learning tridharma, i.e., education that covers curricular instructional, co-curicular and extra-curricular activities, research, and community service. In the educational activity in the classroom, the development of character is done using integrated approaches in all lectures. Especially for Civics Education, in keeping with its co-curricular mission that it develops values and attitudes, then the character development has to become the main focus that can use various strategies/methods of character education. Civics Education in the institute of higher learning, epistemologically even strengthens the basis of its ontological basis. The first content confirms the academic and ideological substantive dimensions. While the second confirms the psycho-pedagogical and socio-cultural dimensions of the discipline of civics education.

b) Using the CIPP model in evaluating Civics Education processes in all public and private universities in Buleleng regency makes the evaluation more objective, especially in proving local culture in developing character education.

c) Using certainty factor method in determining the extent or degree of certainty of a component that is being evaluated in Civics Education process will produce a more objective and optimal evaluation.

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Blurring and Deblurring Digital Images Using the Dihedral Group

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***Abstract*—A new method of blurring and deblurring digital images is presented. The approach is based on using new filters generating from average filter and H-filters using the action of the dihedral group. These filters are called HB-filters; used to cause a motion blur and then deblurring affected images. Also, enhancing images using HB-filters is presented as compared to other methods like Average, Gaussian, and Motion. Results and analysis show that the HB-filters are better in peak signal to noise ratio (PSNR) and RMSE.**

Keywords—Dihedral group; Kronecker Product; motion blur and deblur; digital image

I. Introduction

This template, There are three main categories of image processing, image enhancement, image compression and restoration and measurement extraction [3,6]. A digital image is divided into pixels. Each pixel has a magnitude that represents intensity. The camera uses the recorded image as a faithful representation of the scene that the user saw, but every image is more or less burry. Blurring may arise in the recording of image, because it is unavoidable the scene information "spills over" to neighboring pixels. When there is motion between the camera and image objects during photographing, the motion blur the image. In order to recover motion-blurred images, mathematical model of blurring process are used [1]. Many authors studied motion blur. Often, it is not easy or convenient to eliminate the blur technically. Mathematically, motion blur is modeled as a convolution of point spread function (filters) denoted by (PSF) with the image represented by its intensities. The original image must be recovered by using mathematical model of the blurring process which is called image deblurring [7]. Many researchers introduced algorithms to remove blur such as Average filter AF (or Mean filter), Gaussian filter (GF). The Gaussian filter is equivalent to filtering with a mask of radius R, whose weights are given by Gaussian function: $(x,y)=\frac{1}{2\pi\sigma^2}e^{\frac{-(x^2+y^2)}{2\sigma^2}}$, $x\in R$; where σ is stander deviation of the Gaussian: large σ for more intensive smoothing) [2]. Motion Blur effect filter is a filter that makes the image appear to be moving by adding a blur in a specific direction [10]. The largest subgroup H of dihedral group D_n is found in [4].

In this work, Markov basis *HB* is used to introduce a new filters from Average filter for adding and removing motion blur of image, denoted by *HB*-filters.

II. Preliminary Concepts

This section reviews the preliminaries about H-filters, Dihedral group, Convolution and Deconvolution processes.

A. H-Filters

H-filters are 18 elements as per the following set [5].

$$\mathbf{z}_1=\begin{bmatrix}1&-1&0\\-1&1&0\\0&0&0\end{bmatrix};\ \mathbf{z}_2=\begin{bmatrix}0&0&0\\1&-1&0\\-1&1&0\end{bmatrix};$$

$$\mathbf{z}_3=\begin{bmatrix}1&0&-1\\-1&0&1\\0&0&0\end{bmatrix};\ \mathbf{z}_4=\begin{bmatrix}0&0&0\\1&0&-1\\-1&0&1\end{bmatrix};$$

$$\mathbf{z}_5=\begin{bmatrix}0&1&-1\\0&-1&1\\0&0&0\end{bmatrix};\ \mathbf{z}_6=\begin{bmatrix}0&1&-1\\0&0&0\\0&-1&1\end{bmatrix};$$

$$\mathbf{z}_7=\begin{bmatrix}0&0&0\\0&1&-1\\0&-1&1\end{bmatrix};\ \mathbf{z}_8=\begin{bmatrix}1&-1&0\\0&0&0\\-1&1&0\end{bmatrix};$$

$$\mathbf{z}_9=\begin{bmatrix}1&0&-1\\0&0&0\\-1&0&1\end{bmatrix};\ \mathbf{z}_{10}=\begin{bmatrix}-1&1&0\\1&-1&0\\0&0&0\end{bmatrix};$$

$$\mathbf{z}_{11}=\begin{bmatrix}0&0&0\\-1&1&0\\1&-1&0\end{bmatrix};\ \mathbf{z}_{12}=\begin{bmatrix}-1&0&1\\1&0&-1\\0&0&0\end{bmatrix};$$

$$\mathbf{z}_{13}=\begin{bmatrix}0&0&0\\-1&0&1\\1&0&-1\end{bmatrix};\ \mathbf{z}_{14}=\begin{bmatrix}0&-1&1\\0&1&-1\\0&0&0\end{bmatrix};$$

$$\mathbf{z}_{15}=\begin{bmatrix}0&-1&1\\0&0&0\\0&1&-1\end{bmatrix};\ \mathbf{z}_{16}=\begin{bmatrix}0&0&0\\0&-1&1\\0&1&-1\end{bmatrix};$$

$$\mathbf{z}_{17}=\begin{bmatrix}-1&1&0\\0&0&0\\1&-1&0\end{bmatrix};\ \mathbf{z}_{18}=\begin{bmatrix}-1&0&1\\0&0&0\\1&0&-1\end{bmatrix};$$

B. Definition 1: Dihedral Group

Let n be a positive integer greater than or equal to 3. The group of all symmetries of the regular polygon with n sides, including both rotations and reflections, is called **dihedral group** and denoted by D_n[13]. The 2n elements in D_n can be written as: $\{e, r, r^2, \ldots, r^{n-1}, s, sr, sr^2, sr^{n-1}\}$, where e is the identity element in D_n. In general, we can write D_n as: $D_n=\{s^j r^k : 0 \le k \le n-1,\ 0 \le j \le 1\}$ which has the following properties:

$r^n = 1$, $sr^k s = r^{-k}$, $(sr^k)^2 = e$, for all $0 \le k \le n-1$. The composition of two elements of the D_n is given by $r^i r^j = r^{i+j}$, $r^i s r^j = sr^{j-i}$, $sr^i r^j = sr^{i+j}$, $sr^i s r^j = r^{j-i}$.

C. 2D Convolution

Assume two discrete 2-dimensional images $f(x, y)$ and $h(x, y)$. Their *convolved* (or *folded*) *sum* is the image $g(x, y)$, the convolution of these two functions is defined as [12]:

$$g(x,y) = f(x,y) \otimes h(x,y) \text{ , so}$$
$$f(x,y) \otimes h(x,y) = \sum_{m=0}^{M-1} \sum_{n=0}^{N-1} f(m,n)\, h(x-m, y-n) \quad (1)$$

For $0 \le x, m \le M-1$; $0 \le y, n \le N-1$,

where $M \times N$ is a size of $h(x,y)$.

III. 2D Discrete Fourier Transform

The two-dimensional *discrete Fourier transform* (DFT) of the image function *f(x, y)* is defined as,

$$F(u,v) = \sum_{x=0}^{M-1} \sum_{y=0}^{N-1} f(x,y)\, e^{-j2\pi(\frac{ux}{M}+\frac{vy}{N})} \quad (2)$$

where *f(x, y)* is a digital image of size $M \times N$, and the discrete variable *u* and *v* in the ranges: *u = 0, 1, 2, …, M-1* and *v = 0, 1, 2, …, N-1*[11].

Given the transform *F(u, v)*, we can obtain *f(x, y)* by using the *inverse discrete Fourier transform* (IDFT):

$$f(x,y) = \frac{1}{MN} \sum_{u=0}^{M-1} \sum_{v=0}^{N-1} F(u,v)\, e^{j2\pi(\frac{ux}{M}+\frac{vy}{N})} \quad (3)$$

It can be shown by direct substitution into Eq. 2 and Eq. 3 that the *Fourier transform* pair satisfies the following translation properties:

$$f(x-m, y-n) \Leftrightarrow F(u,v) e^{-i2\pi\left(\frac{um}{M}+\frac{vn}{N}\right)} \quad (4)$$

Now, interested in finding the Fourier transform of Eq. 1:

$$\mathcal{F}\big(f(x,y) \otimes h(x,y)\big) = \sum_{x=0}^{M-1} \sum_{y=0}^{N-1} \Big[\sum_{m=0}^{M-1} \sum_{n=0}^{N-1} f(m,n)\, h(x-m, y-n)\Big] e^{-j2\pi\left(\frac{ux}{M}+\frac{vy}{N}\right)}$$

, so by Eq. 4 we have,

$$\mathcal{F}\big(f(x,y) \otimes h(x,y)\big) = \sum_{m=0}^{M-1} \sum_{n=0}^{N-1} f(m,n)\, H(u,v)\, e^{-j2\pi(\frac{ux}{M}+\frac{vy}{N})} = F(u,v)\, H(u,v) .$$

This result of the *convolution theorem* is written as:

$$f(x,y) \otimes h(x,y) \Longleftrightarrow F(u,v) H(u,v) \quad (5)$$

The transform of the original image simply by dividing the transform of the degraded image $G(u,v)$, by the degradation function $H(u,v)$ is

$$\hat{F}(u,v) = \frac{G(u,v)}{H(u,v)} \quad (6)$$

that's called inverse filter [9].

A. Fourier Spectrum

Because the 2-D *DFT* is complex in general [8], it can be expressed in polar form: $F(u,v) = |F(u,v)| e^{-i\emptyset(u,v)}$

where the magnitude,

$$|F(u,v)| = [R^2(u,v) + I^2(u,v)]^{\frac{1}{2}} \quad (7)$$

is called the Fourier (or frequency) spectrum. The power spectrum is defined as,

$$P(u.v) = |F(u,v)|^2 = R^2(u,v) + I^2(u,v).$$

As before, *R and J* are the real and imaginary parts of *F(u, v)* and all computations are carried out for the discrete variables *u* = 0, 1, 2, ... , *M* -1 and *v* = 0,1,2, ... , *N*-1. Therefore,

$|F(u, v)|$, $\emptyset(u,v)$, and $P(u, v)$ are arrays of size $M \times N$.

B. Image Restoration based on Wiener Deconvolution

The method considers images and noise as random variables, and the objective is to find an estimate $\hat{f}$ of the uncorrupted image f such that the mean square error *(MSE)* between them is minimized. This error measure is given by:

$$e^2 = E\left\{\left(f - \hat{f}\right)^2\right\} \quad (8)$$

Based on these conditions, the minimum of the error function in Eq. 8 is given in the frequency domain by the expression:

$$\hat{F}(u,v) = \left[\frac{H^*(u,v) S_f(u,v)}{S_f(u,v)|H(u,v)|^2 + S_\eta(u,v)}\right] G(u,v)$$
$$= \left[\frac{1}{H(u,v)} \frac{|H(u,v)|^2}{|H(u,v)|^2 + S_\eta(u,v)/S_f(u,v)}\right] G(u,v) \quad (9)$$

The terms in Eq. 9 are as follows:

H(u,v) = degradation function& $H^*(u,v)$ = complex conjugate of H(u, v)& $|H(u,v)|^2 = H^*(u,v)H(u,v)$ & $S_\eta(u,v) = |N(u,v)|^2$ = power spectrum of the noise& $S_f(u,v) = |F(u,v)|^2$ = power spectrum of the original image& *G(u, v)*= the transform of the degraded image. Note that if the noise is zero, then the noise power spectrum vanishes and the Wiener filter reduces to the inverse filter.

IV. The Proposed Approach

H-filters are used to generate ***HB-filters*** by adding each element in ***H-filters*** to the average filter, so we got some ***HB-filters*** with dimensions *3-by-3* and each of which has type of blur different from the other.

Then the ***HB-filters*** can be extended using tenser product (by operation ⊛) to larger sizes, in order to get a higher degrees of blur in digital images. Take any one of ***HB-filters*** *h(x,y)* of dimension *3-by-3* and extend it by identity matrix I_n, *n-by-n* where *n* is an odd number greater than or equals 3, by Tensor Product *T*:

$$T(x,y) = h(x,y) \circledast I_n(x,y)$$
$$= \begin{bmatrix} h_{11} \times I_n & h_{12} \times I_n & h_{13} \times I_n \\ h_{21} \times I_n & h_{22} \times I_n & h_{23} \times I_n \\ h_{31} \times I_n & h_{32} \times I_n & h_{33} \times I_n \end{bmatrix}_{3n \times 3n}$$

This filter will be called ***extended HB-filter*** generated from ***HB-filter*** *h(x,y)* and I_n **.**

Example 1.

Choose any one of ***H-filters***: $\mathbf{z}_2 = \begin{bmatrix} 0 & 0 & 0 \\ 1 & -1 & 0 \\ -1 & 1 & 0 \end{bmatrix}$

Divide $\mathbf{z}_2$ by 9, and add it to the average filter (A_f) as follows:

$$h_1 = \boldsymbol{z_2} + \boldsymbol{A_f} = \begin{bmatrix} 0 & 0 & 0 \\ 1 & -1 & 0 \\ -1 & 1 & 0 \end{bmatrix} \Big/ 9 + \begin{bmatrix} 1 & 1 & 1 \\ 1 & 1 & 1 \\ 1 & 1 & 1 \end{bmatrix} \Big/ 9 =$$

$\begin{bmatrix} 1 & 1 & 1 \\ 2 & 0 & 1 \\ 0 & 2 & 1 \end{bmatrix} \Big/ 9$. So, $h_1 = \begin{bmatrix} 1 & 1 & 1 \\ 2 & 0 & 1 \\ 0 & 2 & 1 \end{bmatrix} \Big/ 9$ it's one of ***HB-filters***.

Now use the action largest subgroup $\boldsymbol{\mathcal{H}} = \{e, r^{\frac{n}{3}}, r^{\frac{2n}{3}}, sr, sr^{1+\frac{n}{3}}, sr^{1+\frac{2n}{3}}\}$ of dihedral group [4], to generate other ***HB-filters***. So, h_1 can be represented as 9-dimensional column vector,

$$h_1 = \begin{bmatrix} 1 \\ 1 \\ 1 \\ 1 \\ 2 \\ 0 \\ 1 \\ 0 \\ 2 \end{bmatrix} \Big/ 9 \in \mathbb{Z}^9 ,$$

and calculate element of $\boldsymbol{\mathcal{H}}$ in D_9 as

$$r^{\frac{n}{3}} = r^3$$

$$= \left(1 \ \ \frac{n}{3}+1 \ \ \frac{2n}{3}+1\right)\left(2 \ \ \frac{n}{3}+2 \ \ \frac{2n}{3}+2\right) \dots \left(\frac{n}{3} \ \ \frac{2n}{3} \ \ n\right)$$

$$= (1\ 4\ 7)(2\ 5\ 8)(3\ 6\ 9) .$$

To find $T_{r^3}h_1$, one has:

$$T_{r^3} = \begin{bmatrix} 0&0&0&0&0&0&1&0&0 \\ 0&0&0&0&0&0&0&1&0 \\ 0&0&0&0&0&0&0&0&1 \\ 1&0&0&0&0&0&0&0&0 \\ 0&1&0&0&0&0&0&0&0 \\ 0&0&1&0&0&0&0&0&0 \\ 0&0&0&1&0&0&0&0&0 \\ 0&0&0&0&1&0&0&0&0 \\ 0&0&0&0&0&1&0&0&0 \end{bmatrix},$$

then

$$T_{r^3}h_1 = \begin{bmatrix} 0&0&0&0&0&0&1&0&0 \\ 0&0&0&0&0&0&0&1&0 \\ 0&0&0&0&0&0&0&0&1 \\ 1&0&0&0&0&0&0&0&0 \\ 0&1&0&0&0&0&0&0&0 \\ 0&0&1&0&0&0&0&0&0 \\ 0&0&0&1&0&0&0&0&0 \\ 0&0&0&0&1&0&0&0&0 \\ 0&0&0&0&0&1&0&0&0 \end{bmatrix} \cdot \begin{bmatrix} 1 \\ 1 \\ 1 \\ 1 \\ 2 \\ 0 \\ 1 \\ 0 \\ 2 \end{bmatrix} \Big/ 9$$

$$= \begin{bmatrix} 1 \\ 0 \\ 2 \\ 1 \\ 1 \\ 1 \\ 1 \\ 2 \\ 0 \end{bmatrix} \Big/ 9 = h_2 ,$$

So, $h_2 = \begin{bmatrix} 1 & 0 & 2 \\ 1 & 1 & 1 \\ 1 & 2 & 0 \end{bmatrix} \Big/ 9 \in \boldsymbol{HB}$

Similarly, one obtains

$$r^{\frac{2n}{3}} = sr^6$$

$$= \left(1 \ \ \tfrac{2n}{3}+1 \ \ \tfrac{n}{3}+1\right)\left(2 \ \ \tfrac{2n}{3}+2 \ \ \tfrac{n}{3}+2\right) \dots \left(\tfrac{n}{3} \ \ n \ \ \tfrac{2n}{3}\right)$$

$$= (1\ 7\ 4)(2\ 8\ 5)(3\ 9\ 6) \cdot h_1 = \begin{bmatrix} 1 & 2 & 0 \\ 1 & 0 & 2 \\ 1 & 1 & 1 \end{bmatrix} \Big/ 9 = h_3 .$$

$$sr = (1\ \ n)(2\ \ n-1) \dots \left(\tfrac{n}{3} \ \ \tfrac{2n}{3}+1\right)\left(\tfrac{n}{3}+1 \ \ \tfrac{2n}{3}\right) \dots \left(\tfrac{n-1}{2} \ \ \tfrac{n+3}{2}\right)$$

$$= (1\ 9)(2\ 8)(3\ 7)(4\ 6)(4\ 6) \cdot h_1 = \begin{bmatrix} 2 & 0 & 1 \\ 0 & 2 & 1 \\ 1 & 1 & 1 \end{bmatrix} \Big/ 9 = h_4 .$$

$$sr^{\frac{n}{3}+1} = sr^4$$

$$= \left(1 \ \ \frac{2n}{3}\right)\left(2 \ \ \frac{2n}{3}-1\right) \dots \left(\frac{n}{3} \ \ \frac{n}{3}+1\right)\left(\frac{2n}{3}+1 \ \ n\right) \dots$$

$$\dots \left(\frac{5n-3}{6} \ \ \frac{5n+9}{6}\right)$$

$$= (1\ \ 6)\ (2\ 5)(3\ 4)\ (7\ 9)(7\ 9) \cdot h_1 = \begin{bmatrix} 0 & 2 & 1 \\ 1 & 1 & 1 \\ 2 & 0 & 1 \end{bmatrix} \Big/ 9 = h_5 .$$

$$sr^{\frac{2n}{3}+1} = \left(1 \ \ \frac{n}{3}\right)\left(2 \ \ \frac{n}{3}-1\right) \cdots \left(\frac{n-3}{6} \ \ \frac{n+9}{6}\right)\left(\frac{n}{3}+1 \ \ n\right) \times$$

$$\times \left(\frac{n}{3}+2 \ \ n-1\right) \cdots \left(\frac{2n}{3} \ \ \frac{2n}{3}+1\right)$$

$$= (1\ 3)\ (2\ 2)\ (1\ 3)\ (4\ 9)\ (5\ 8)\ (6\ 7) \cdot h_1$$

$$= \begin{bmatrix} 1 & 1 & 1 \\ 2 & 0 & 1 \\ 0 & 2 & 1 \end{bmatrix} \Big/ 9 = h_6$$

All of these filters belong to ***HB-filters***.

Most ***HB-filters*** can be obtained using other ***H-filters***. For example the ***extended HB-filters*** generated from ***HB-filter***

$h(x,y) = \begin{bmatrix} 2 & 0 & 1 \\ 0 & 2 & 1 \\ 1 & 1 & 1 \end{bmatrix}$ with I_3 is given by

$$T(x,y)=h(x,y)\circledast I_3(x,y)=\begin{bmatrix}2&0&1\\0&2&1\\1&1&1\end{bmatrix}\circledast\begin{bmatrix}1&0&0\\0&1&0\\0&0&1\end{bmatrix}$$

$$=\begin{bmatrix}2&0&0&0&0&0&1&0&0\\0&2&0&0&0&0&0&1&0\\0&0&2&0&0&0&0&0&1\\0&0&0&2&0&0&1&0&0\\0&0&0&0&2&0&0&1&0\\0&0&0&0&0&2&0&0&1\\1&0&0&1&0&0&1&0&0\\0&1&0&0&1&0&0&1&0\\0&0&1&0&0&1&0&0&1\end{bmatrix}_{9\times 9}$$

A. Blurring

This sub-section describes the standard filters algorithm for addition blur of an image by using the convolution theorem.

Blur algorithm

Consider an image matrix *f(x, y)* of dimension *m-by-n*, which can be written as follows:

$$f(x,y)=\begin{bmatrix}f_{11}&\cdots&f_{1n}\\\vdots&\ddots&\vdots\\f_m&\cdots&f_{mn}\end{bmatrix}_{m\times n}$$. And ***HB-filter*** *h(x,y)* *p-by-q* dimension defined as, $h(x,y)=\begin{bmatrix}h_{11}&h_{12}&\cdots&h_{1q}\\h_{21}&h_{22}&\cdots&h_{2q}\\\vdots&\vdots&\ddots&\vdots\\h_{p1}&h_{p2}&\cdots&h_{pq}\end{bmatrix}_{p\times q}$.

Step1: In the beginning add *f(x,y)* by *p-1* rows with zeros from up and down, and *p-1* columns with zeros from left and right, such that the result is *{m+2(p-1)}-by-{n+2(q-1)}* dimensions, as follows:

$$f(x,y)=\begin{bmatrix}0&0&0\ \ldots&0&0&0_{1j}\\\vdots&\vdots&\vdots\ \ldots&0&0&0\\0&\cdots&f_{11}&f_{1n}&\vdots&\vdots\\\vdots&&\vdots\ \ddots&\vdots&&\\0&0&f_{m1}\ldots&f_{mn}&&\\&&0&0&0&0\\0_{i1}&0&0&0&0&0_{ij}\end{bmatrix}_{i\times j},$$

where *i= m+2(p-1)* and *j= m+2(q-1)*.

Step2: Reverse $h(x,y)$ (that used in blurring) for two directions,

$$h(x,y)=\begin{bmatrix}h_{11}&h_{12}&\cdots&h_{1q}\\h_{21}&h_{22}&\cdots&h_{2q}\\\vdots&\vdots&\ddots&\vdots\\h_{p1}&h_{p2}&\cdots&h_{pq}\end{bmatrix}$$

$$\xRightarrow{rev} h(x,y)=\begin{bmatrix}h_{pq}&\cdots&h_{p2}&h_{p1}\\h_{2q}&\cdots&h_{22}&h_{21}\\\vdots&\ddots&\vdots&\vdots\\h_{1q}&\cdots&h_{12}&h_{11}\end{bmatrix}_{p\times q}$$

Step3: Make the two arrays as follows:

$$h(x,y)=\begin{bmatrix}h_{pq}&\cdots&h_{p2}&h_{p1}\\h_{2q}&\cdots&h_{22}&h_{21}\\\vdots&\ddots&\vdots&\vdots\\h_{1q}&\cdots&h_{12}&h_{11}\end{bmatrix}$$

$$f(x,y)=\begin{bmatrix}0&\cdots&0_{1q}&0&0&\cdots&0\\0&\cdots&0&0&0&0&0\\\vdots&\ddots&\vdots&\vdots&\vdots&0&0\\0_{p1}&\ldots&f_{11}&f_{12}&0&0&0\\\vdots&\cdots&\vdots&\vdots&0&0&\vdots\\0&&f_{m1}&f_{m2}&\ddots&\vdots&\vdots\\0&\vdots&\vdots&\vdots&\vdots&0&0\\0&0&0&0&0&0&0\end{bmatrix}_{i\times j}.$$

Step4: Calculate the convolution equation for all pixels of blurred matrix *g(x,y)*:

$$g(x,y)=f(x,y)\otimes h(x,y)=\sum_{i=1}^{p}\sum_{j=1}^{q}f(i,j)h(i,j)$$

So,

$$\begin{aligned}g(1,1)=&\left(0\times h_{pq}\right)+\left(0\times h_{p2}\right)+\left(0\times h_{p1}\right)+\left(0\times h_{2p}\right)\\&+\cdots+(0\times h_{22})+(0\times h_{21})+\left(0\times h_{1q}\right)\\&+\cdots+(0\times h_{12})+(f_{11}\times h_{11})\\=&(f_{11}\times h_{11}).\end{aligned}$$

After that shift the filter *h(x,y)* as much as one column as follows:

$$h(x,y)=\begin{bmatrix}h_{pq}&\cdots&h_{p2}&h_{p1}\\h_{2q}&\cdots&h_{22}&h_{21}\\\vdots&\ddots&\vdots&\vdots\\h_{1q}&\cdots&h_{12}&h_{11}\end{bmatrix}$$

$$f(x,y)=\begin{bmatrix}0&0&\cdots&0\ \ldots&0&0&0_{1j}\\&\vdots&\ddots&\vdots\ \ldots&0&0&0\\0&0&f_{11}&f_{12}&f_{1n}&\vdots&\\\vdots&\vdots&\vdots&\vdots\ \ddots&\vdots&\vdots&\vdots\\0&0&f_{m1}&f_{m2}\ldots&f_{mn}&&\\0&0&0&0&0&0&0\\0_{i1}&0&0&0&0&0&0_{ij}\end{bmatrix}_{i\times j}$$

Also,

$$\begin{aligned}g(1,2)=&\left(0\times h_{pq}\right)+\cdots+\left(0\times h_{p2}\right)+\left(0\times h_{p1}\right)\\&+\left(0\times h_{2q}\right)+\cdots+(0\times h_{22})+(0\times h_{21})\\&+\cdots+\left(0\times h_{1q}\right)+\cdots+(f_{11}\times h_{12})\\&+(f_{12}\times h_{11})=(f_{11}\times h_{12})+(f_{12}\times h_{11})\end{aligned}$$

Now repeat step 4 to obtain digital image convolution *g(x,y)* at all times that the two arrays overlap. We continue until we find *g(r, c)*, where *r & c=m+ (p-1)*, then the final form of the blurred matrix *g(x,y)* is:

$$g(x,y)=\begin{bmatrix}g_{11}&\cdots&g_{1c}\\\vdots&\ddots&\vdots\\g_r&\cdots&g_{rc}\end{bmatrix}_{r\times c}.$$

Step5: Delete from *g(x,y)* as much as $\frac{p-1}{2}$ rows from up and down, and $\frac{p-1}{2}$ columns from left and right, such that the blurred matrix *g(x,y)* becomes *m-by-n* in dimension:

$$g(x,y)=\begin{bmatrix}g_{11}&\cdots&g_{1n}\\\vdots&\ddots&\vdots\\g_m&\cdots&g_{mn}\end{bmatrix}_{m\times n}.$$

Example 2.

Suppose the image matrix *f(x,y)* is:

$f(x,y) = \begin{bmatrix} 209 & 90 & 60 \\ 0 & 77 & 30 \\ 100 & 46 & 20 \end{bmatrix}_{3\times3}$. We blur this matrix with one of the ***HB-filters***: $h(x,y) = \begin{bmatrix} 2 & 0 & 1 \\ 0 & 2 & 1 \\ 1 & 1 & 1 \end{bmatrix}/9$.

Step1: Add two rows from up and down, and two columns from left and right of zeros for the matrix *f(x, y)*, such that becomes *7-by-7* dimension, as follows:

$$f(x,y) = \begin{bmatrix} 0 & 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 209 & 90 & 60 & 0 & 0 \\ 0 & 0 & 0 & 77 & 30 & 0 & 0 \\ 0 & 0 & 100 & 46 & 20 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & 0 \end{bmatrix}_{7\times7} .$$

Step2: Reverse the filter *h(x,y)* for two directions:

$$h(x,y) = \begin{bmatrix} 2 & 0 & 1 \\ 0 & 2 & 1 \\ 1 & 1 & 1 \end{bmatrix}/9 \overset{rev}{\Longrightarrow} \begin{bmatrix} 1 & 1 & 1 \\ 1 & 2 & 0 \\ 1 & 0 & 2 \end{bmatrix}/9$$

Step3: Make the two arrays, as the following form:

$$h(x,y) = \begin{bmatrix} 1 & 1 & 1 \\ 1 & 2 & 0 \\ 1 & 0 & 2 \end{bmatrix}/9$$

$$f(x,y) = \begin{bmatrix} 0 & 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 209 & 90 & 60 & 0 & 0 \\ 0 & 0 & 0 & 77 & 30 & 0 & 0 \\ 0 & 0 & 100 & 46 & 20 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & 0 \end{bmatrix}_{7\times7}$$

Step4: Calculate the convolution equation for all pixels of blurred matrix *g(x,y)*:

$$g(x,y) = f(x,y) \otimes h(x,y) = \sum_{m_1=1}^{3}\sum_{n_1=1}^{3} f(m_1,n_1)h(m_1,n_1)$$

Now, $g(1,1) = (209 \times 0.2222) = 26.4444$

After that, shift the filter *h(x,y)* as much as one column, then repeat the same step.

So, $g(1,2) = (90 \times 0.2222) = 20$

$g(1,3) = (209 \times 0.1111) + (60 \times 0.2222) = 36.5556$

$\vdots$

$g(5,5) = (20 \times 0.2222) = 2.2222$

The final form of the blurred matrix $g(x,y)$ is:

$$\begin{bmatrix} 46.4444 & 20 & 36.5556 & 10 & 6.6667 \\ 0 & 63.5556 & 94.8889 & 31.8889 & 10 \\ 45.4444 & 43.4444 & 72.5556 & 37 & 12.2222 \\ 0 & 30.7778 & 33.2222 & 21.4444 & 5.5556 \\ 11.1111 & 16.2222 & 18.444 & 7.3333 & 2.2222 \end{bmatrix}_{5\times5}$$

Step5: Delete from *g(x,y)* as much as *one* row from up and down, and *one* column from left and right, such that the result is the blurred matrix $g_1(x,y)$ *3-by-3* dimension,

$$g_1(x,y) = \begin{bmatrix} 63.5556 & 49.39 & 31.57 \\ 43.4444 & 72.5556 & 37 \\ 30.7778 & 33.2222 & 21.4444 \end{bmatrix}_{3\times3} .$$

B. Deblurring

Here we express the proposed deblurring method.

Deblur Algorithm

Weiner deconvolution for the matrix *g(x,y)* and *h(x,y)* is given by:

$$\hat{F}(u,v) = \left[\frac{1}{H(u,v)}\frac{|H(u,v)|^2}{|H(u,v)|^2 + S_\eta(u,v)/S_f(u,v)}\right] G(u,v) \ .$$

Suppose there is no noise (i.e.$\frac{S_\eta(u,v)}{S_f(u,v)} = 0$), then the noise of power spectrum vanishes and the Weiner reduces to the invers filter, so one has: $\hat{F}(u,v) = \frac{G(u,v)}{H(u,v)}$.

Step 1: Find Fourier transform of the blurred matrix *g(x,y)* *r-by-c* dimensions,

$$G(u,v) = \sum_{x=1}^{m}\sum_{y=1}^{n} g(x,y)\, e^{-j2\pi(\frac{ux}{M}+\frac{vy}{N})} \ .$$

Step 2: Find Fourier transform of **HB-filter** h(x,y).

$$H(u,v) = \sum_{x=1}^{m}\sum_{y=1}^{n} h(x,y)\, e^{-j2\pi(\frac{ux}{M}+\frac{vy}{N})},$$

If the dimension of *h(x,y)* is less than dimension of *g(x,y)*, we will add zeros for *h(x,y)* to create as same as the dimension of the image matrix *g(x,y)* before doing the transform, such that the result is *m-by-n* in dimension.

Step 3: Calculate the transform of estimated image $\hat{F}(u,v)$.

Step 4: Find estimated image $\hat{f}(x,y)$ by taking inverse Fourier transform of $\hat{F}(u,v)$, by follows:

$$\hat{f}(x,y) = \frac{1}{MN}\sum_{u=1}^{m}\sum_{v=1}^{n} \hat{F}(u,v)\, e^{j2\pi(\frac{ux}{M}+\frac{vy}{N})} \ .$$

Step 5: Remove zeros from $\hat{f}(x,y)$as much as $(p-1)/2$ of last rows and columns, where resulted dimensions equal to dimensions original image matrix *f(x,y)*.

Example 2. We will take blurred matrix *g(x,y)* from ex.2,

$$g(x,y) = \begin{bmatrix} 46.4444 & 20 & 36.5556 & 10 & 6.6667 \\ 0 & 63.5556 & 94.8889 & 31.8889 & 10 \\ 45.4444 & 43.4444 & 72.5556 & 37 & 12.2222 \\ 0 & 30.7778 & 33.2222 & 21.4444 & 5.5556 \\ 11.1111 & 16.2222 & 18.444 & 7.3333 & 2.2222 \end{bmatrix}_{5\times5} ,$$

with ***HB-filter***, $h(x,y) = \begin{bmatrix} 2 & 0 & 1 \\ 0 & 2 & 1 \\ 1 & 1 & 1 \end{bmatrix}_{3\times3} /9$.

Now, from the Weiner equation, suppose that $\frac{S_\eta(u,v)}{S_f(u,v)} = 0$, then the Weiner reduces to the invers filter as following, $\hat{F}(u,v) = \frac{G(u,v)}{H(u,v)}$.

Step 1: Find Fourier transform of the matrix $g(x,y)$,

$$G(u,v) = \sum_{x=1}^{m}\sum_{y=1}^{n} g(x,y)\, e^{-j2\pi(\frac{ux}{M}+\frac{vy}{N})}$$

Now, $G(1,1) = \sum_{x=1}^{5}\sum_{y=1}^{5} g(x,y)\, e^{-j2\pi\left(\frac{x}{5}+\frac{y}{5}\right)}$

$$= \left(g(1,1)e^{-j2\pi\left(\frac{1}{5}+\frac{1}{5}\right)}\right) + \left(g(1,2)e^{-j2\pi\left(\frac{1}{5}+\frac{2}{5}\right)}\right) + \left(g(1,3)e^{-j2\pi\left(\frac{1}{5}+\frac{3}{5}\right)}\right) + \left(g(1,4)e^{-j2\pi\left(\frac{1}{5}+\frac{4}{5}\right)}\right) + \cdots + \left(g(5,5)e^{-j2\pi\left(\frac{5}{5}+\frac{5}{5}\right)}\right)$$

$$= 46.4444e^{-j\left(\frac{4}{5}\right)\pi} + 20e^{-j\left(\frac{6}{5}\right)\pi} + 36.5556e^{-j\left(\frac{8}{5}\right)\pi} + 10e^{-j2\pi} + \cdots + 2.2222e^{-j4\pi} = 632 + 0j$$

$$G(1,2) = \sum_{x=1}^{5}\sum_{y=1}^{5} g(x,y)\, e^{-j2\pi\left(\frac{x}{5}+\frac{2y}{5}\right)} = -89.44 - 191.15j$$

$$G(1,3) = \sum_{x=1}^{5}\sum_{y=1}^{5} g(x,y)\, e^{-j2\pi\left(\frac{x}{5}+\frac{3y}{5}\right)} = 30.94 + 17.24\text{j}$$

⋮

$$G(5,5) = \sum_{x=1}^{5}\sum_{y=1}^{5} g(x,y)\, e^{-j2\pi\left(\frac{5x}{5}+\frac{5y}{5}\right)} = -1.13 - 45.84\text{j}$$

So, the final form of *G (u,v)* be

$$\begin{bmatrix} 632+0j & -89.44-191.15j & 30.94+17.24j & 30.94-17.24j & -89.44+191.15j \\ -59.29-165.44j & -1.13+45.84j & 7.69+13.15 & 17.02+4.9j & 101.27+20.83j \\ 42.45-55.03j & 31.43+42.17j & 42.35+97.85j & 98.29+36.24j & 42.97+17.47j \\ 42.45-55.03j & 42.97-17.47j & 98.29-36.24j & 42.35-97.85j & 31.43-42.17j \\ -59.29+165.44j & 101.27-20.83j & 17.02-4.9j & 7.69-13.15j & -1.13-45.84j \end{bmatrix}_{5\times5}$$

Step 2: Because of the dimension of *h(x,y)* is less than dimension of *g(x,y)*, then add zeros for *h(x,y)* to create as same as the dimensions of the image matrix *g(x,y)*, so we have:

$$h(x,y) = \begin{bmatrix} 2 & 0 & 1 & 0 & 0 \\ 0 & 2 & 1 & 0 & 0 \\ 1 & 1 & 1 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 \end{bmatrix}_{5\times5} \Big/ 9,$$

After that, we are doing the Fourier transform of *h(x,y)*:

$H(u,v) = \sum_{x=1}^{m}\sum_{y=1}^{n} h(x,y)\, e^{-j2\pi\left(\frac{ux}{M}+\frac{vy}{N}\right)}$

Now, $H(1,1) = \sum_{x=1}^{5}\sum_{y=1}^{5} h(x,y)\, e^{-j2\pi\left(\frac{x}{5}+\frac{y}{5}\right)}$

$$= \left(h(1,1)e^{-j2\pi\left(\frac{1}{5}+\frac{1}{5}\right)}\right) + \left(h(1,2)e^{-j2\pi\left(\frac{1}{5}+\frac{2}{5}\right)}\right) + \left(h(1,3)e^{-j2\pi\left(\frac{1}{5}+\frac{3}{5}\right)}\right) + \left(h(1,4)e^{-j2\pi\left(\frac{1}{5}+\frac{4}{5}\right)}\right) + \cdots + \left(h(5,5)e^{-j2\pi\left(\frac{5}{5}+\frac{5}{5}\right)}\right)$$

$$= 2e^{-j\left(\frac{4}{5}\right)\pi} + 0e^{-j\left(\frac{6}{5}\right)\pi} + 1e^{-j\left(\frac{8}{5}\right)\pi} + 0e^{-j2\pi} + \cdots + 0e^{-j4\pi} = 1 + 0j$$

$$H(1,2) = \sum_{x=1}^{5}\sum_{y=1}^{5} h(x,y)\, e^{-j2\pi\left(\frac{x}{5}+\frac{2y}{5}\right)} = 0.1667 - 0.5129j$$

$$H(1,3) = \sum_{x=1}^{5}\sum_{y=1}^{5} h(x,y)\, e^{-j2\pi\left(\frac{x}{5}+\frac{3y}{5}\right)} = 0.1667 + 0.1211j$$

⋮

$$H(5,5) = \sum_{x=1}^{5}\sum_{y=1}^{5} h(x,y)\, e^{-j2\pi\left(\frac{5x}{5}+\frac{5y}{5}\right)} = -0.2828 + 0.0249j$$

So, the final form of *H(u,v)* is:

$$H(u,v) = \begin{bmatrix} 1+0j & 0.1667-0.5129j & 0.1667+0.1211j & 0.1667-0.1211j & 0.1667+0.5129j \\ 0.1667-0.5129j & -0.2828-0.0249j & 0.1667+0.171j & 0.1667+0.0404j & 0.4444+0j \\ 0.1667+0.1211j & 0.1667+0.171j & 0.3383+0.2767j & 0.4444+0j & 0.1667-0.0404j \\ 0.1667-0.1211j & 0.1667+0.0404j & 0.4444+0j & 0.3383-0.2767j & 0.1667-0.171j \\ 0.1667+0.5129j & 0.4444-0j & 0.1667-0.0404j & 0.1667-0.171j & -0.2828+0.0249j \end{bmatrix}_{5\times5}$$

Step 3: Calculate the Fourier transform of estimated image.

$$\hat{F}(u,v) = G(u,v)/H(u,v) = \begin{bmatrix} 632+0\text{j} & 285.83-267.23\text{j} & 170.67-20.58\text{j} & 170.67+20.58\text{j} & 285.83+267.23\text{j} \\ 257.77-199.34j & -10.23-161.21j & 61.93+15.37j & 103.17+4.41j & 227.85+46.87j \\ 323.73+94.98j & 218.33+29.01j & 216.73+111.98j & 221.15+81.54j & 219.57+158.02j \\ 323.73-94.98j & 219.57-158.02j & 221.15-81.54j & 216.73-111.98j & 218.33-29.01j \\ 257.77+199.34j & 227.85-46.87j & 103.17-4.41j & 61.93-15.37j & -10.23+161.21j \end{bmatrix}_{5\times5}$$

Step 4: Find inverse Fourier transform with only real numbers $\hat{f}(x,y)$ of an array $\hat{F}(u,v)$.

$\hat{f}(x,y) = \frac{1}{MN}\sum_{u=1}^{m}\sum_{v=1}^{n} \hat{F}(u,v)\, e^{j2\pi(\frac{ux}{M}+\frac{vy}{N})}$,

So,

$$\hat{f}(1,1) = \frac{1}{5\times5}\sum_{u=1}^{m}\sum_{v=1}^{n} \hat{F}(u,v)\, e^{j2\pi\left(\frac{u}{5}+\frac{v}{5}\right)} = \frac{1}{5\times5}\left(\hat{F}(1,1)e^{j2\pi\left(\frac{1}{5}+\frac{1}{5}\right)} + \hat{F}(1,2)e^{j2\pi\left(\frac{1}{5}+\frac{2}{5}\right)} + \hat{F}(1,3)e^{j2\pi\left(\frac{1}{5}+\frac{3}{5}\right)} + \cdots + \hat{F}(5,5)e^{j2\pi\left(\frac{5}{5}+\frac{5}{5}\right)}\right)$$

$$= \frac{1}{25}\left((632+0\text{j})e^{j\left(\frac{4}{5}\right)\pi} + (285.83 - 267.23\text{j})e^{j\left(\frac{6}{5}\right)\pi} + (170.67 - 20.58\text{j})e^{j\left(\frac{8}{5}\right)\pi} + \cdots + (-10.23 + 161.12\text{j})e^{j4\pi}\right) = 209$$

$\hat{f}(1,2) = 90$

$\hat{f}(1,3) = 60$

⋮

$\hat{f}(5,5) = 0$

Now, the final of estimated image $\hat{f}(x,y)$ is $\hat{f}(x,y) = \begin{bmatrix} 209 & 90 & 60 & 0 & 0 \\ 0 & 77 & 30 & 0 & 0 \\ 100 & 46 & 20 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 \end{bmatrix}_{5\times5}$.

Step 5: Remove the last two rows and columns of zeros from $\hat{f}(x,y)$:

$\hat{f}(x,y) = \begin{bmatrix} 209 & 90 & 60 \\ 0 & 77 & 30 \\ 100 & 46 & 20 \end{bmatrix}_{3\times3}$, where the original matrix *f(x,y)* is: $g(x,y) = \begin{bmatrix} 209 & 90 & 60 \\ 0 & 77 & 30 \\ 100 & 46 & 20 \end{bmatrix}_{3\times3}$.

Now, we give the (original, blurred, estimated) block image to explain the image enhancement in ex.2 and ex.3 as shown in Fig.1.

Fig. 1. Image blocks in ex.2 & ex.3. Left: original image f(x,y). Middle: blurred g(x,y). Right: estimated image $\hat{f}(x, y)$

TABLE I. THE COMPARISON OF BETWEEN DIFFERENT FILTERS

	Degree of blur	Image blur	Aver. filter	Gauss. filter	Motion filter	Proposed filter
PSNR	9×9	21.44	7.25	21.45	13.78	45.53
	21×21	18.03	7.01	18.04	12.7	49.9
	27×27	17.02	7.03	17.02	11.79	46.23
RMSE	9×9	21.61	110.66	21.58	52.18	1.35
	21×21	31.98	113.72	31.96	59.1	0.81
	27×27	35.95	113.45	35.94	65.65	1.24

C. Comparison with other filters

HB-filters are compared in PNSR (in dB) and RMSE with the (*AF*, *GF*, and *MF*) filters. The proposed method and the other methods are applied on (256× 256) Pepper RGB image, by using (jpg. format) as in Table I. The application of proposed method and some other methods on the color images (in jpg. format) of different blur is shown in Fig.2.

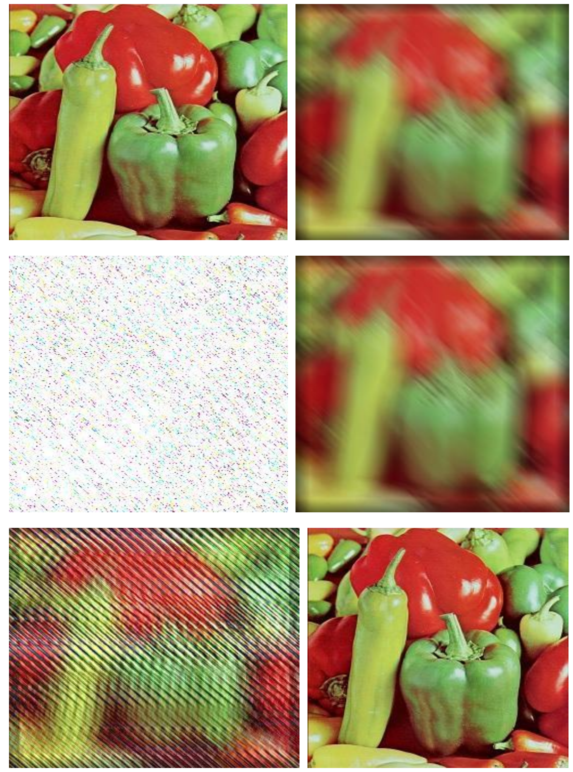

Fig. 2. Application on Pepper (jpg. format) RGB image with degree of blur 27*27. Top Left: Original. Top Right: Blur image PSNR=17.02, RMSE=35.95. Middle Left: A.F, PSNR=7.03, RMSE=113.45. Middle Right: G.F, PSNR=17.02, RMSE =35.94> Bottom Left: M.F, PSNR=11.79, RMSE =65.65. Bottom Right: Proposed, PSNR=46.23, RMSE=1.24

V. CONLCLUSION

Nlur has been added and removed from digital images using HB-filters. The HB-filters perform well for grayscale, binary and color (jpg, png) images with different blur degrees. Results show that the HB method has higher PSNR and less RMSE than Average, Gaussian and Motion methods.

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Naive Bayes Classifier Algorithm Approach for Mapping Poor Families Potential

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***Abstract*—The poverty rate that was recorded high in Indonesia becomes main priority the government to find a solution to poverty rate was below 10%. Initial identification the potential poverty becomes a very important thing to anticipate the amount of the poverty rate. Naive Bayes Classifier (NBC) algorithm was one of data mining algorithms that can be used to perform classifications the family poor with 11 indicators with three classifications. This study using sample data of poor families a total of 219 data. A system that built use Java programming compared to the result of Weka software with accuracy the results of classification of 93%. The results of classification data of poor families mapped by adding latitude-longitude data and a photograph of the house of the condition of poor families. Based on the results of mapping classifications using NBC can help the government in Kabupaten Bantul in examining the potential of poor people.**

Keywords—Data Mining; Naive Bayes; Poverty Potential; Mapping

I. INTRODUCTION

Poverty in Indonesia has a number that is still quite high, above 10% [12]. It is becoming a top priority for the government to find solutions to reduce the poverty rate is below 10% [2]. Central Statistics Bureau (BPS) defines poverty as the inability to meet the minimum standards of basic needs that include food and non-food needs. BPS showed that the poverty rate in Indonesia, in September 2014, was still high at about 27.7 million people, or approximately 10.96% [11]. The poverty data graph shown in Figure 1.

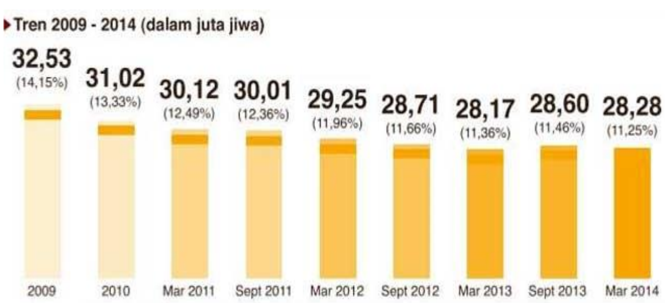


Fig. 1. Poverty Data Graph in Indonesia (bps.go.id)

The number of poor people in Indonesia are mostly locate in Java island with a total of 57.8% of the total number of poor people in Indonesia, and it is located in Yogyakarta province. Poverty measurement in each country or even in every region that does not have the same size [8][9]. The poverty measurement that called as the poverty indicator becomes the most important part in determining poverty status [8][9]. In Bantul, which is one district in Yogyakarta has a fairly high poverty rate, above 14%.

The determination in classifying the poverty status of someone is the tough section that needs hard effort because it must represent the accurate results. Naive Bayes Classifier is one of the data mining algorithms that uses probabilistic approach [1][4][5]. This research will discuss how Naive Bayes Classifier algorithm can classify the status of poor families to identify potential poverty based on existing indicators. There were 11 indicators of poor families used in this study, and each of them has certain value [10]. The indicators were food, clothing, shelter, income, health, education, wealth (rupiah), property (land), water, electricity and the number of family members. While the classification used is very poor, poor and vulnerable poor [10][12].

II. LITERATURE REVIEW

A. Poverty

Poverty is a matter of deprivation or problematic deficiencies. Poverty is a condition where a person or a family is in a state of deprivation [2][9]. From these definitions, poverty can be divided into two parts: absolute and relative,

a) Absolute poverty is defined as the inability to achieve a minimum standard of life. Understanding the needs of different minimum standards in each country.

b) Relative poverty, on the other hand, is defined as the inability to achieve the standards of contemporary needs , which is linked to the welfare-rata average or average income community planning at the time.

Based on the data, the factors are distinguished into the data that affect poverty in the countryside and in urban areas, too. The comparison is important because poverty does not only happen in rural area but also in urban area. Based on this geographical approach, then poverty can be differentiated into poverty in rural and urban areas.

a) Rural poverty is a poverty which has the characteristics such as: i) limited access to the ground facilities and irrigation, ii) the slow adaptation to modern technology, iii) too large burden borne, iv) limited human capital, v) only concentrated in rural areas and vi) only concentrated on certain ethnic minorities [9].

b) Urban poverty is a poverty which has the characteristics such as: i) have limited access to resources and services, ii) limited human resources quality, iii) too large burden borne, iv) the low wages earned, v) big amount of the disorganized small enterprises and vi) a big amount of groups that do not have the capability [9].

B. Data Mining

Data Mining as a process to obtain useful information from a data warehouse [6] [7]. The term data mining is often called knowledge discovery. One technique that is made in data mining is to explore existing data to build a model and then use that model in order to identify the pattern of other data that is not stored in the database [6].

C. Naive Bayes Classifer (NBC)

Naive Bayes Classifier estimates the conditional class opportunities which assume that the attributes are conditionally independent and given the class label *Y* [3][5] Conditional independent assumptions can be expressed in the following form :

$$P(X|Y=y)=\prod_{i=1}^{d} P(X_i|Y=y) \quad \text{..............................} \quad (1)$$

each set of attributes consisting of *d* attributes. There is a special treatment before the features with numeric data types are put into Naive Bayes. The first way is to use discretization and the assumption of a Gaussian distribution. Gaussian distribution was chosen to represent the conditional probability that a continuous feature in a class independency P(Xi|Y). This Gaussian distribution approach was used by the researcher to obtain a probability value of each poverty indicator.

Generics Naive Bayes Classifier Algorithms:

1) *Read attributes and class of the data set.*

2) *Calculate the posterior probability of each attribute to an existing class.*

3) *Calculate the probability pior of existing classes.*

4) *Calculate the multiplication value of the posterior probability of each class and the value prior to all existing classes.*

5) *Find the greatest probability value in step four as the final classification.*

III. METHODOLOGY

The data has used in this study taken from the poor families in the Kabupaten Bantul. The overall system can be seen in the block diagram that existed at Figure 2.

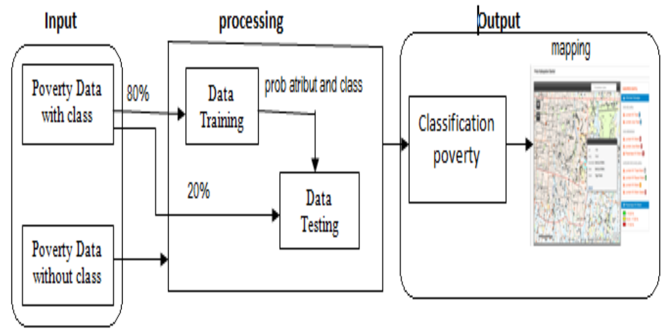


Fig. 2. Diagram Block System

The block diagram system represented in Figure 2 was divided into three parts. The first part was the data input which was consisted of three classes of poverty (poverty status) and the poverty data which would be used for identification. Poverty classes consist of very poor, poor and vulnerable poor. The number of parameters for classification was composed from 11 indicators as presented on Table 1.

TABLE I. POVERTY INDICATOR

No	Indicator	Indicator Score
1	Food	(0,12)
2	Clothing	(0,9)
3	Shelter	(0,9)
4	Income	(0,35)
5	Health	(0,6)
6	Education	(0,6)
7	Wealth (Rupiah)	(0,5)
8	Property (Land)	(0,6)
9	Water	(0,4)
10	Electricity	(0,3)
11	Number of Familly members	(0,5)

There were 219 data which were divided into two parts: 80% (175 data) were used for training data and 20% (approximately 44 data) were used for data testing. The second part was the main process of Naive Bayes Classifier that calculated a probability value to be used for classification. The calculated data was the training data set. The training phase results were in the form of probability values which would be used for testing.

Phase testing was done to see the accuracy of the obtained classification. The third section resulted the classification of the poverty class which would be mapped to see the poverty potential in an area by using Google Maps.

The training process (training) on the algorithm of Naive Bayes Classifier (NBC) can be seen in Figure 3.

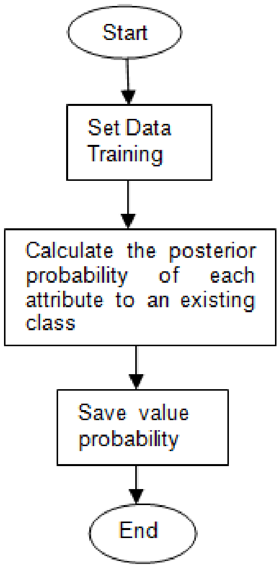


Fig. 3. Training Fase Naive Bayes

Figure 3, showed the step-by-step process of Naïve Bayes Classifier algorithm which included reading the data sets. The display of training data is shown in Figure 4.

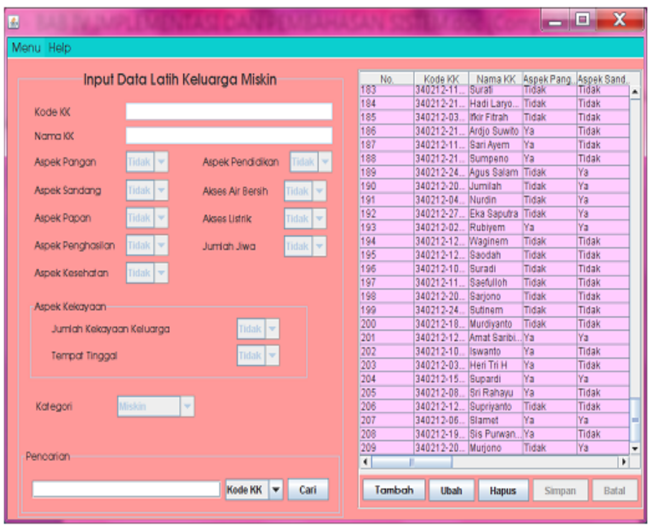


Fig. 4. Data Training Display

The training input from the indicators was Yes and No category which can be seen in Figure 4. Input yes represent value a score largest while value not represent value a score smallest (see. indicator score in table 1). Whereas for the testing process can be shown in Figure 5. The data used for testing were as much as 20% which was approximately 44 data from 219 data.

The results of the testing phase was used to calculate the probability of each classification by using a probability value obtained in the training phase to determine the poverty classification results by taking the smallest probability. In the testing phase, it can be seen that the high accuracy of the identification of the poor people status in Kabupaten Bantul. Figure 6 represented the display of testing menu interface.

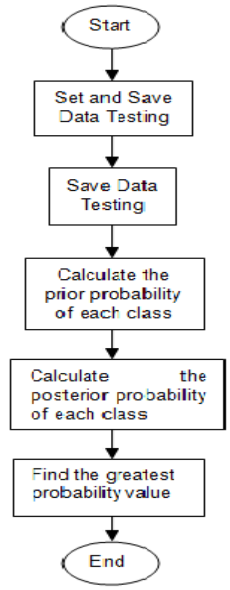


Fig. 5. Testing Fase Naive Bayes

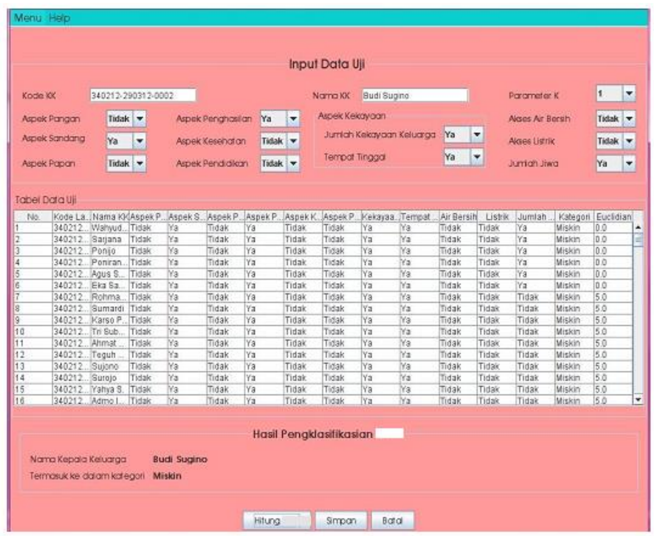
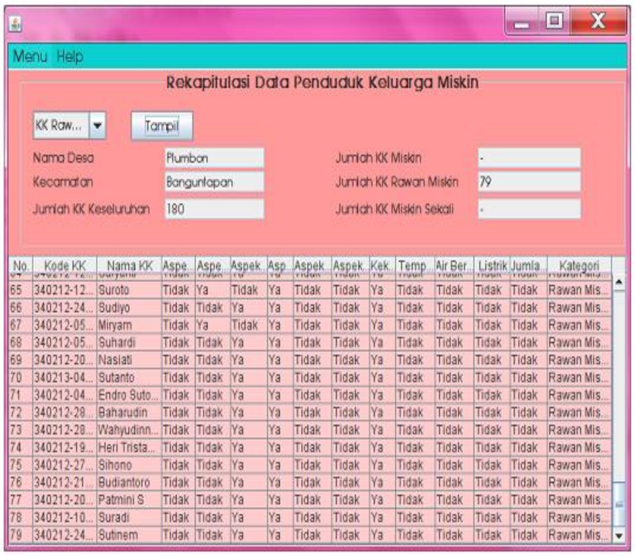


Fig. 6. Data Testing Display

IV. Result and Discussion

The implementation of Naïve Bayes algorithm to determine the classification of poverty was built using Java. These results were used as the input for mapping poor families.These results would be mapped using Google Maps by adding the data ordinates (latitude and longitude) location of a poor family. The results of testing the classification of the data shown in Figure 7 were presented in the form of recapitulation.

From the results of the data testing, the accuracy of the data was 92.5% which came from the data of 44 poor people from the total amount of 219 poor residents. Results of existing data were also compared with the results from the Weka software. Before the data were being processed, preprocessing the data was done previously. This stage was done to look at the description of the data which needs to be processed using NBC. The description of statistical data showed that the data to be processed had an average value 1.804 and a standards deviation value of 2.869. From this value, it was indicated that the deviation of the data is very high. After preprocessing being done, then classification analysis was done using Naive Bayes Classifier (NBC) algorithm. From Weka data testing results in Figure 8, it was shown that the classification results had the accuracy of 93.18%.



No.	Kode KK	Nama KK	Aspe...	Aspe...	Aspek...	Asp...	Aspek...	Aspek...	Kek...	Temp...	Air Ber...	Listrik	Jumla...	Kategori
65	340212-12...	Suroto	Tidak	Ya	Tidak	Ya	Tidak	Tidak	Ya	Tidak	Tidak	Tidak	Tidak	Rawan Mis...
66	340212-24...	Sudiyo	Tidak	Tidak	Ya	Ya	Tidak	Tidak	Ya	Tidak	Tidak	Tidak	Tidak	Rawan Mis...
67	340212-05...	Miryam	Tidak	Ya	Tidak	Ya	Tidak	Tidak	Ya	Tidak	Tidak	Tidak	Tidak	Rawan Mis...
68	340212-05...	Suhardi	Tidak	Tidak	Ya	Ya	Tidak	Tidak	Ya	Tidak	Tidak	Tidak	Tidak	Rawan Mis...
69	340212-20...	Nasiati	Tidak	Tidak	Ya	Ya	Tidak	Tidak	Ya	Tidak	Tidak	Tidak	Tidak	Rawan Mis...
70	340213-04...	Sutanto	Tidak	Tidak	Ya	Ya	Tidak	Tidak	Ya	Tidak	Tidak	Tidak	Tidak	Rawan Mis...
71	340212-04...	Endro Suto...	Tidak	Tidak	Ya	Ya	Tidak	Tidak	Ya	Tidak	Tidak	Tidak	Tidak	Rawan Mis...
72	340212-28...	Baharudin	Tidak	Tidak	Ya	Ya	Tidak	Tidak	Ya	Tidak	Tidak	Tidak	Tidak	Rawan Mis...
73	340212-28...	Wahyudinn...	Tidak	Tidak	Ya	Ya	Tidak	Tidak	Ya	Tidak	Tidak	Tidak	Tidak	Rawan Mis...
74	340212-19...	Heri Trista...	Tidak	Tidak	Ya	Ya	Tidak	Tidak	Ya	Tidak	Tidak	Tidak	Tidak	Rawan Mis...
75	340212-27...	Sihono	Tidak	Tidak	Ya	Ya	Tidak	Tidak	Ya	Tidak	Tidak	Tidak	Tidak	Rawan Mis...
76	340212-21...	Budiantoro	Tidak	Tidak	Ya	Ya	Tidak	Tidak	Ya	Tidak	Tidak	Tidak	Tidak	Rawan Mis...
77	340212-20...	Patmini S	Tidak	Tidak	Ya	Ya	Tidak	Tidak	Ya	Tidak	Tidak	Tidak	Tidak	Rawan Mis...
78	340212-10...	Suradi	Tidak	Tidak	Ya	Ya	Tidak	Tidak	Ya	Tidak	Tidak	Tidak	Tidak	Rawan Mis...
79	340212-24...	Sutinem	Tidak	Tidak	Ya	Ya	Tidak	Tidak	Ya	Tidak	Tidak	Tidak	Tidak	Rawan Mis...

Fig. 7. Result Testing Rekapitulation

From 44 data tested using Weka, there were 41 data that could be recognized correctly, while there were 3 data that could not be identified. The results of the classification in Figure 7 were used as the input for mapping the poor families by adding the data latitude and longitude as well as home photo of the poor families.

```
inst#,    actual, predicted, error, probability distribution
    1        2:M      1:RM      +  *0.817  0.183  0
    2        2:M      2:M          0.003 *0.997  0
    3        2:M      2:M          0.027 *0.973  0
    4        2:M      2:M          0.011 *0.989  0
    5        2:M      2:M          0      *1      0
    6        1:RM     1:RM        *0.824  0.176  0
    7        1:RM     1:RM        *0.84   0.16   0
    8        2:M      2:M          0.191 *0.809  0
    9        2:M      2:M          0.21  *0.79   0
   10        1:RM     1:RM        *0.824  0.176  0
   11        1:RM     1:RM        *0.84   0.16   0
   12        1:RM     1:RM        *0.824  0.176  0
   13        2:M      2:M          0.004 *0.996  0
   14        1:RM     1:RM        *0.824  0.176  0
   15        2:M      1:RM      +  *0.974  0.026  0
   16        2:M      2:M          0.191 *0.809  0
   17        2:M      2:M          0.001 *0.999  0
   18        2:M      2:M          0.011 *0.989  0
   19        2:M      2:M          0.21  *0.79   0
   20        2:M      2:M          0.018 *0.982  0
   21        2:M      2:M          0.184 *0.816  0
   22        2:M      2:M          0.003 *0.997  0
   23        2:M      2:M          0.001 *0.999  0
   24        1:RM     1:RM        *0.84   0.16   0
   25        2:M      2:M          0.001 *0.999  0
   26        1:RM     1:RM        *0.84   0.16   0
   27        2:M      2:M          0.21  *0.79   0
   28        1:RM     1:RM        *0.84   0.16   0
   29        2:M      2:M          0.191 *0.809  0
   30        2:M      2:M          0.001 *0.999  0
   31        1:RM     1:RM        *0.824  0.176  0
   32        1:RM     1:RM        *0.84   0.16   0
   33        2:M      2:M          0.003 *0.997  0
   34        1:RM     1:RM        *0.824  0.176  0
   35        2:M      2:M          0.135 *0.865  0
   36        2:M      2:M          0.001 *0.999  0
   37        1:RM     1:RM        *0.84   0.16   0
   38        2:M      2:M          0.002 *0.998  0
   39        1:RM     1:RM        *0.84   0.16   0
   40        2:M      1:RM      +  *0.817  0.183  0
   41        2:M      2:M          0.001 *0.999  0
   42        1:RM     1:RM        *0.824  0.176  0
   43        2:M      2:M          0.005 *0.995  0
   44        1:RM     1:RM        *0.994  0.006  0

=== Evaluation on test split ===
=== Summary ===

Correctly Classified Instances          41               93.1818 %
Incorrectly Classified Instances         3                6.8182 %
Kappa statistic                          0.8584
Mean absolute error                      0.1021
```

Fig. 8. Weka Output

The mapping displays of the poor families were shown in Figure 9 and Figure 10. Figure 9 shows the location mapping of the poor families for all categories of poverty in a certain area. This mapping information will describe the potential of the existing poverty in a certain region. Figure 10 provides detailed information about a poor family that includes Family Identification Number, Name of the head of the family, the home location and home photos of poor families.

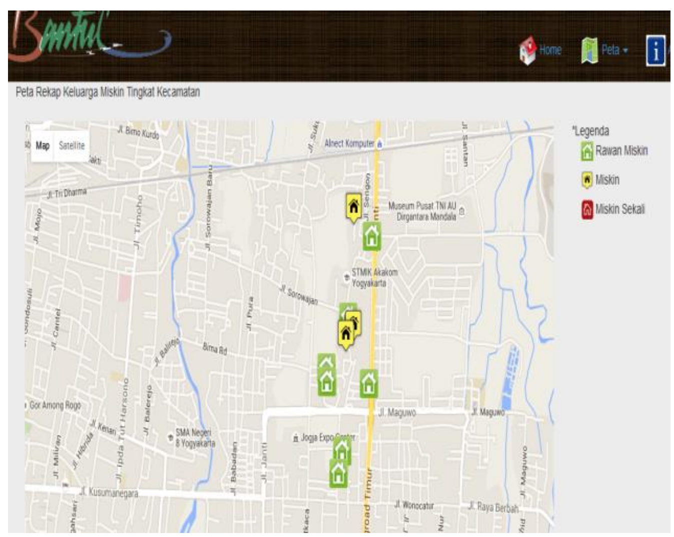


Fig. 9. Poverty Mapping

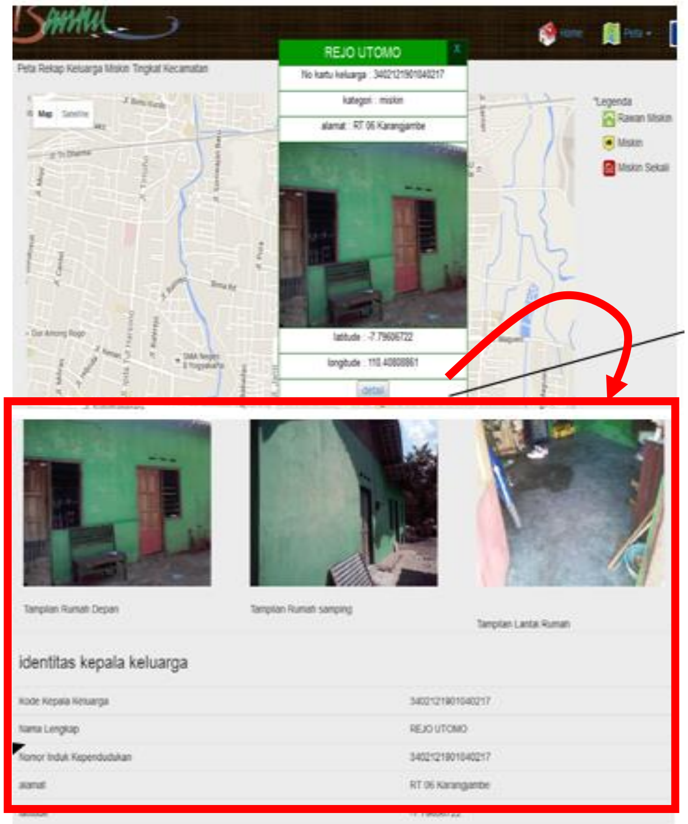


Fig. 10. Detail Information Poor Family

This detailed data will provide benefits for decision makers in providing aid or poverty reduction solutions.

V. Conclusion

From the explanation that is in chapter before it can be taken conclusion on the results of the study among other:

a) Method Naive Bayes Classifier can do classifications the determination of their position in the family poor with the accuracy 93%.

b) Classifications produced on data testing only two classifications that are 25 poor and 19 prone to poor, where 41 data recognizable by right and 3 data could not identified.

c) Mapping and detailed information from the classifications into Google Maps can inform us about the potential of poverty in areas.

d) The implementation of Naive Bayes Classifier algorithm built use Java used by the decision makers who is in Kabupaten Bantul.

Acknowledgment

We want to thank to SKPD BKKPPKB in Kabupaten Bantul which has given the opportunity to do research in the field of poverty.

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Language Identification by Using SIFT Features

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***Abstract*—Two novel techniques for language identification of both, machine printed and handwritten document images, are presented. Language identification is the procedure where the language of a given document image is recognized and the appropriate language label is returned. In the proposed approaches, the main body size of the characters for each document image is determined, and accordingly, a sliding window is used, in order to extract the SIFT local features. Once a large number of features have been extracted from the training set, a visual vocabulary is created, by clustering the feature space. Data clustering is performed using K-means or Gaussian Mixture Models and the Expectation - Maximization algorithm. For each document image, a Bag of Visual Words or Fisher Vector representation is constructed, using the visual vocabulary and the extracted features of the document image. Finally, a multi class Support Vector Machine classification scheme is used, to score the system. Experiments are performed on well-known databases and comparative results with another established technique, are also given.**

***Keywords*—Document image processing; language identification; SIFT features; bag of Visual Words; Fisher Vector**

I. Introduction

There is no doubt that nowadays all services tend to become even more digitalized. There is a growing trend for many multinational companies or organizations to digitalize their old documents or books and store them in digital databases. These documents could be either handwritten or machine printed and usually in various languages. Google Books [1] is an example. Language identification is a very important task, as it could help to index and/or sort a big digital document corpus in a convenient way.

In the area of optical character recognition (OCR), most of the works assume that the language of the document is known beforehand. In this case, document language identification could be used as a valuable pre-processing task, in order to determine the correct language and eventually utilize the appropriate OCR engine for text extraction, translation and/or indexing.

The difficulty of language identification is highly dependent on the languages themselves. For example, a machine printed Chinese document is easily separated from a machine printed English document, since the local language structure, words and the shape of the letters, differ vastly in these two languages. Many papers have been published to address this issue.

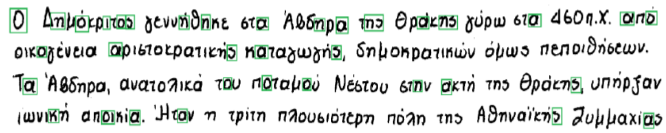
Ο Δημόκριτος γεννήθηκε στα Άβδηρα της Θράκης γύρω στο 460π.Χ. από
οικογένεια αριστοκρατικής καταγωγής, δημοκρατικών όμως πεποιθήσεων.
Τα Άβδηρα, ανατολικά του ποταμού Νέστου στην ακτή της Θράκης, υπήρξαν
ιωνική αποικία. Ήταν η τρίτη πλουσιότερη πόλη της Αθηναϊκής Συμμαχίας

Fig. 1. Handwritten Greek text

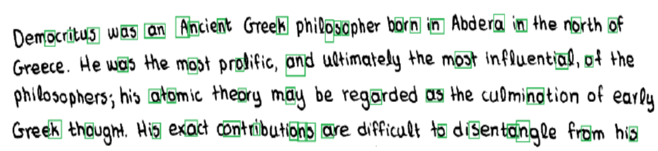
Democritus was an Ancient Greek philosopher born in Abdera in the north of
Greece. He was the most prolific, and ultimately the most influential, of the
philosophers; his atomic theory may be regarded as the culmination of early
Greek thought. His exact contributions are difficult to disentangle from his

Fig. 2. Handwritten English text

In this paper, we focus on languages that are not very distant from each other and even share many common letters, like e.g. English and Greek. In Fig 1 and 2, common letters are noted, to show the very small intra-class variation.

To the best of our knowledge, most of the published work puts great emphasis on machine printed text that is also very linguistically diverse. The proposed works could be classified considering the methodology they are based on: a) Template Matching [2,3] b) Texture Analysis [4,5] and c) Shape Codebooks [6].

Hochberg et al. [2-3] presented a system for language identification matching cluster-based templates. In this work, they aim to discover repeating linguistic features like characters and word shapes in each script. To do so, they create fixed-size templates (textual symbols) from the training set, by clustering similar symbols together and representing each cluster by its centroid. They score the system by matching a subset of symbols to the templates. The reported results show high accuracy on a machine printed text corpus.

Texture analysis has also been proposed for the task of language identification. In [4], G. S. Peake et al. propose a segmentation-free approach. They used grey level co-occurrence matrices and Gabor filters in order to extract features. For classification, a K-NN classifier is used and they reported fair results on machine printed content. In [5], A. Busch et al. extracted wavelet co-occurrence features from small blocks of machine printed text and used a Gaussian Mixture Model (GMM) classifier to score the system. They reported good results, but on small machine printed textual regions and not on the whole document pages. More similar work on texture analysis can be found in [7, 8].

In [6], Zhu et al. propose a segmentation-free language identification system for both handwritten and machine printed documents for 8 languages. They extract local features that called Triple Adjacent Contours (TAS) from document images and form a shape codebook by clustering that feature space. They use that codebook to create an image descriptor for each document image. This descriptor is basically a statistical representation of the frequency that each TAS feature occurs on the image. They use a Support Vector Machine (SVM) for the classification process. They don't show how it performs on languages with low intra class-variation like Greek and English, but they report exceptional results on a wide language variety.

Apart from the aforementioned work, there are also a considerable number of other papers trying to address this problem, based mostly on line analysis of textual features. Projection profiles are being explored in [9] and upward concavities in [10]. These approaches usually require some preprocessing, like skew correction.

In this paper, two systems for the task of Language identification are presented. The first one is based on the Bag of Visual Features (BoVF) [11]. The second approach is based on representing the images using Fisher Vectors (FV) [12-13] created by a GMM visual vocabulary. For these two approaches, a Support Vector Machine classification scheme is used to score the system. Both methods share many similarities, however they perform differently.

The two systems are presented in the sections II and III, respectively, while the experimental results are analyzed in section IV. Finally our conclusions are drawn in section V.

II. Language Identification Using Bag of Visual Features

The Bag of Visual Features (BoVF) is one of the suggested methods for generic Image categorization based on image content. This particular method is widely applied in scene and object categorization as well as image retrieval [14-15]. The Bag of Visual Features has been inspired from the Bag of Words of the area of Natural Language Processing that is used for text classification. Generally speaking, the mentioned systems are trying to extract relevant features from the images in order to create a histogram representation of every image (Fig.3) that will be used as input to a classifier.

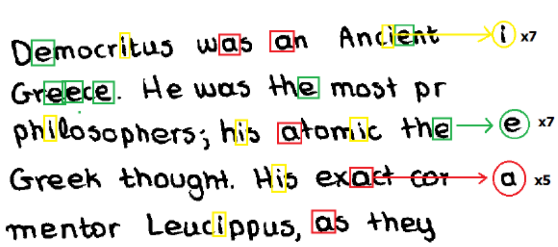

Fig. 3. To represent an image as a Bag of Visual Features, each feature is mapped to the nearest image feature/word cluster. All the information of each document image is finally included in e.g. 300 features, out of the e.g. 500-1000 clusters of Visual Features

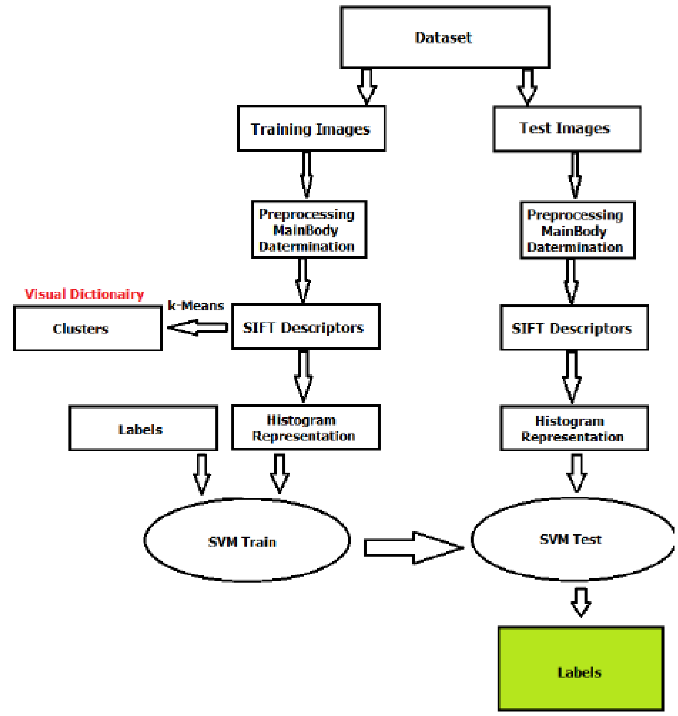

Fig. 4. The Bag of Visual Features approach

The BoVF system that we implement consists of the following steps:

1) A Preprocessing step for every document image that determines the Main Body size of the characters.

2) Feature Extraction for every document image.

3) Creation of a visual vocabulary using k-means.

4) Histogram creation for every document image, which represents the frequency of the visual features in the image.

5) Training of an SVM classification scheme that will be fed with the histograms. The BoVF is a method that only the feature appearance frequency is used from the image without taking into consideration the natural position of every feature on the image. However, in our application, the position of the objects is not important. In Fig.4, the proposed Bag-of-Visual-Feature approach is shown.

The first step consists of the application of the Main Body detection algorithm, described in [16], to the document image. This will return a number n which indicates how tall is the main body of the majority of the characters in the image. During the feature extraction procedure, this information is used in order to create a nxn sliding window to dense sample the image for SIFT features using the algorithm in [17].

1) The SIFT Descriptor is a spatial histogram with 4x4 bins. By setting the size of sliding window to nxn, which is given by the main body detection algorithm, actually the SIFT descriptor is computed in a 4nx4n pixel area (Fig.5).

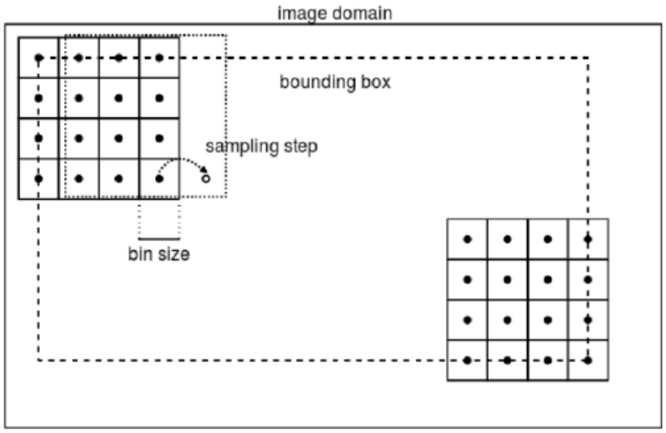

Fig. 5. Dense SIFT descriptor geometry [18]

This step proved to be particularly important as the document images within a class (same language) have quite similar main body estimations. This scheme creates a more personalized and more sophisticated local descriptor within a class, which creates more unique patterns inside the data and maximizes the inter-class variation, while at the same time the intra-class variation is minimized.

The SIFT descriptor is used, since it is sufficiently robust against noise, as well as scale and rotation invariant, which is very important, especially when we have to deal with badly scanned document images. Finally, the SIFT descriptor is 128-dimensional, which maintains as much information as possible and a more distinctive image representation is achieved.

The visual vocabulary can be thought as a big dictionary that contains visual words (features) from the training set. After a feature is extracted from an image, the visual vocabulary is used in order to map this image feature to the closest cluster. An extreme approach would be to compare every image feature to every feature from the training space. However, this is quite unlikely to happen as the feature space from the training set is extremely large and such a task would be computationally expensive. In order to shrink the feature space and create a comprehensive codebook, k-means is used. As usually, it is hard to define how many clusters are enough for the task. Tests with several k values have to be performed to decide, which the correct value for our data is (section 4).

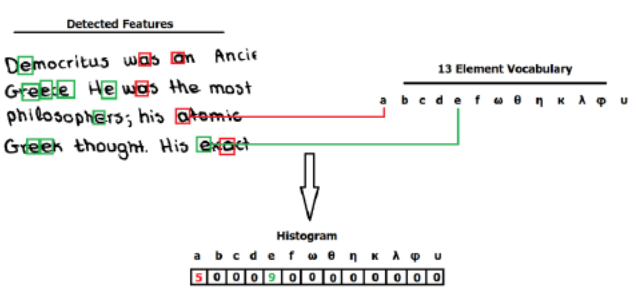

Fig. 6. Histogram creation

Once the visual vocabulary is created, the image representation follows. For every image, the features are extracted. For every feature, the closest entry in the visual vocabulary is detected. The Euclidean distance is used to define how close the visual feature to each cluster is. The size of the resulting histogram for each image equals to the size of the dictionary (Fig.6). However, the histogram is usually very sparse, since most of the words of the visual vocabulary are too distant to match with an image feature, especially if they belong to a different language. As a result, some bins of the histogram are overpopulated, while all the others have small or null values. This high variance could cause trouble to the classifier so the histogram is normalized to *1*.

The Classification is the last task of the proposed system. An one- against -all SVM classification is used. The idea behind one-against-all approach is, to train Support Vector Machine models each one separating one class from the rest. Every time, the classifier with the largest decision value is chosen. During training, the classifier is fed with the training histograms and their labels (1/-1). During the testing process, the test histograms are provided and the predicted label is received.

III. LANGUAGE IDENTIFICATION USING FISHER VECTOR

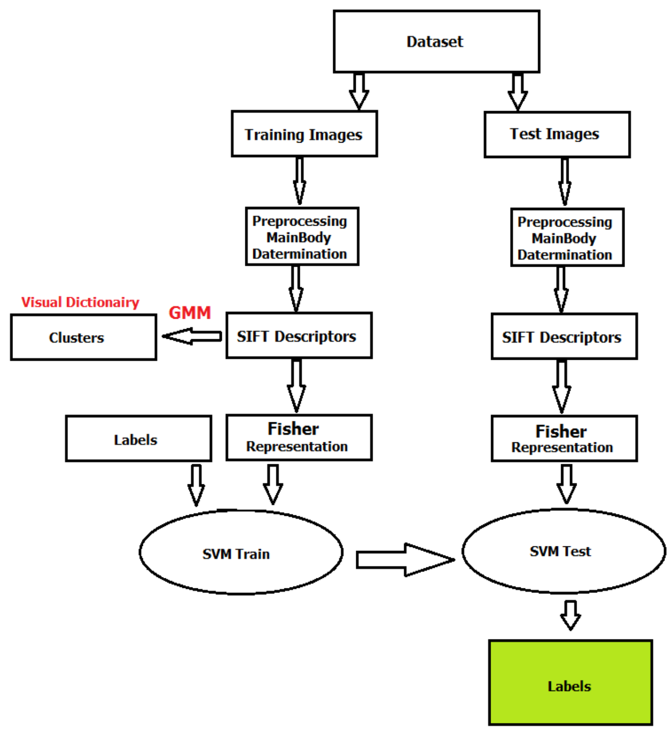

Fig. 7. The Fisher Vector approach

The Fisher Vector (FV) system is basically an extension to the Bag of Visual Features approach. However, it differs a lot, when it comes to create the visual vocabulary and to represent the images. Here, the visual vocabulary is created by training clusters using the Gaussian Mixture Models (GMM). Following the clustering, the images are represented by Fisher Vectors. In this section, the procedure that builds a Fisher vector, using the clustering given by a GMM, is presented. The other tasks have been analyzed in the previous section.

Thus, Fisher Vector pipeline consists of the following steps:

- A Preprocessing step for every document image that help us to determine the Main Body size of the characters.
- Feature Extraction for every document image.
- Creation of a visual vocabulary using Gaussian Mixture Models.
- Fisher Vector representation is created for every document image.
- Training of an SVM classification scheme that will be fed with the Fisher vectors.

In Fig.7 the proposed approach is shown.

In [13], a new algorithm for image representation using the FV is introduced, given local image descriptors and a GMM probabilistic vocabulary. This algorithm as it is used in our approach is described in Fig.8. The dimensionality of this image descriptor is K(2D+1), where K is the number of GMM clusters and D the dimensions of the local image descriptor. Thus, the D is 128, due to the SIFT descriptor, but the K also needs to be determined through experiments (section 4).

Input:

- Local image descriptors $X = \{ x_t \in R^D , t = 1, \ldots. T\}$,
- Gaussian Mixture model parameters $\lambda = \{w_k, \mu_k, \sigma_k, k = 1, \ldots, K\}$

Output:

- Normalized Fisher Vector representation $G_\lambda^X \in R^{K(2D+1)}$

1. Compute Statistics

- For $k = 1, \ldots., K$ initialize accumulators
  - i. $S_k^0 = 0, S_k^1 = 0, S_k^2 = 0$
- For $t = 1, \ldots T$
  - i. Compute $\gamma_t(k)$ using (3.4.1.1.1 formula, 6)
  - ii. For $k = 1, \ldots T$
    - $S_k^0 = S_k^0 + \gamma_t(k)$,
    - $S_k^1 = S_k^1 + \gamma_t(k) x_t$,
    - $S_k^2 = S_k^2 + \gamma_t(k) x_t^2$

2. Compute Fisher Vector Signature

- For $k = 1, \ldots., K$:

$$G_{\alpha_k}^X = (S_k^0 - T w_k)/\sqrt{w_k}$$
$$G_{\mu_k}^X = (S_k^1 - \mu_k S_k^0)/\sqrt{w_k \sigma_k}$$
$$G_{\sigma_k}^X = (S_k^2 - 2\mu_k S_k^1 + (\mu_k^2 - \sigma_k^2)/\sqrt{2 w_k \sigma_k^2}$$

- Concatenate all Fisher vector components into one vector

$$G_\lambda^X = (G_{\alpha_1}^X, \ldots, G_{\alpha_K}^X, G_{\mu_1}^{X'}, \ldots, G_{\mu_K}^{X'}, G_{\sigma_1}^{X'}, \ldots, G_{\sigma_K}^{X'})$$

3. Apply normalizations

- For $i = 1, \ldots, K(2D+1)$ apply power normalization

$$[G_\lambda^X]_i \leftarrow sign([G_\lambda^X]_i \sqrt{[G_\lambda^X]_i})$$

- Apply $l_2 - normalization$

$$G_\lambda^X = G_\lambda^X / \sqrt{G_\lambda^{X'} G_\lambda^X}$$

Fig. 8. The algorithm for the Fisher Vector system

IV. Experimental Results

In order to evaluate these systems, three different datasets are used. The first is a labmade dataset that consists of machine printed text in Greek, English and Arabic document images that have been taken randomly from papers and e-books all over the web. It contains 120 test images, 40 from each language, and 180 training images, 60 from each language. This is a high resolution dataset. The second is the dataset of ICDAR2013 Handwriting Segmentation Contest [19]. This one also consists of high resolution images of handwritten text in English, Greek and Indian. It contains 150 test images, 50 from each language, and 200 training images, 75 from each language. The third dataset was intended to be as close as possible to the one described in [6], in order to give comparative results. In order To evaluate the performance of our multiclass SVM classifier and to score the system, confusion matrixes and the accuracy rate were used.

A. The Bag of Visual Feature System

First, it examined how the results are affected by the window size. The goal is to determine the window size in relation to the main body size, as a natural normalization of the writing style. Once the optimal size is determined, then, additional experiments will be performed in order to evaluate the size of the vocabulary.

Roughly, around 600-700 SIFT features are extracted from each image. This step of the algorithm is particularly time consuming, since the images have been taken in high resolution. However, trying to keep preprocessing as low as possible, image resizing techniques that would probably cause valuable information loss were not applied.

In this experiment, the size of the codebook was kept relatively small at the fixed value of k=50, while performing experimenting with the following rectangular window sizes: main body x 1, main body x 2 and round(main body x 0.5). In tables 1-3, the results are shown on Labmade dataset, while in Fig.9 the accuracy graph for those values is presented.

TABLE I. Data Set= Labmade, K=50, Window=Main Body X 1, SVM C Parameter = 0.0001

Labmade Data Set		Predicted Class: Greek	Predicted Class: English	Predicted Class: Arabic
Actual Class	Greek	0.525	0.35	0.125
	English	0.3	0.55	0.15
	Arabic	0.175	0.125	0.70
Mean Diagonal Accuracy : 59.16%				

TABLE II. DATA SET= LABMADE, K=50, WINDOW = MAIN BODY X 2 , SVM C PARAMETER = 0.0001

Labmade Data Set		Predicted Class		
		Greek	English	Arabic
Actual Class	Greek	0.475	0.325	0.20
	English	0.35	0.525	0.125
	Arabic	0.2	0.125	0.675
Mean Diagonal Accuracy : 55.83%				

TABLE III. DATA SET= LABMADE, K=50, WINDOW =ROUND(MAIN BODYX0.5), SVM C PARAMETER = 0.0001

Labmade Data Set		Predicted Class		
		Greek	English	Arabic
Actual Class	Greek	0.45	0.35	0.20
	English	0.375	0.475	0.15
	Arabic	0.175	0.15	0.675
Mean Diagonal Accuracy : 53.33%				

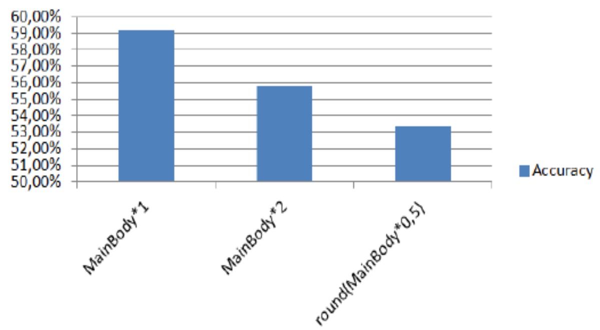

Fig. 9. Collective Accuracy Graph

It is clear that the highest accuracy was obtained by using the rectangular window with size main bodyx1. The results look quite low, since the visual vocabulary contained 50 visual words, only. In the following experiments the sliding window will constantly set at this size, while the vocabulary size will be increased from 100 to 2000 features. The results of this experiment are presented in tables 4-8, while the accuracy graph is shown in Fig.10.

TABLE IV. DATA SET= LABMADE, *K*=100, *WINDOW = MAIN BODY X 1*, SVM *C* PARAMETER = 0.0001

Labmade Data Set		Predicted Class		
		Greek	English	Arabic
Actual Class	Greek	0.65	0.225	0.125
	English	0.175	0.675	0.15
	Arabic	0.2	0.075	0.725
Mean Diagonal Accuracy : 68.33%				

TABLE V. DATA SET= LABMADE, K=200, WINDOW = MAIN BODY X 1, SVM C PARAMETER = 0.0001

Homemade Data Set		Predicted Class		
		Greek	English	Arabic
Actual Class	Greek	0.70	0.20	0.10
	English	0.175	0.75	0.075
	Arabic	0.10	0.075	0.825
Mean Diagonal Accuracy : 75.83%				

TABLE VI. DATA SET= LABMADE, K=500, WINDOW = MAIN BODY X 1, SVM C PARAMETER = 0.0001

Homemade Data Set		Predicted Class		
		Greek	English	Arabic
Actual Class	Greek	0.8	0.15	0.05
	English	0.125	0.825	0.05
	Arabic	0.075	0.025	0.9
Mean Diagonal Accuracy : 84.16%				

TABLE VII. DATA SET= LABMADE, *K*=1000, *WINDOW* =*MAIN BODY X 1* , SVM *C* PARAMETER = 0.0001

Labmade Data Set		Predicted Class: Greek	English	Arabic
Actual Class	Greek	0.85	0.125	0.025
	English	0.1	0.875	0.025
	Arabic	0.025	0.025	0.95
Mean Diagonal Accuracy : 89.16%				

TABLE VIII. DATA SET= LABMADE, *K*=2000, *WINDOW* = *MAIN BODY X 1*, SVM *C* PARAMETER = 0.0001

Labmade Data Set		Predicted Class: Greek	English	Arabic
Actual Class	Greek	0.875	0.075	0.05
	English	0.075	0.90	0.025
	Arabic	0.025	0.025	0.95
Mean Diagonal Accuracy : 90.83%				

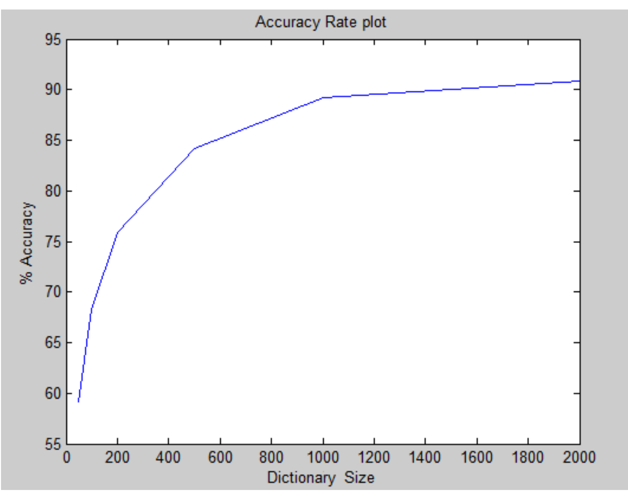

Fig. 10. Accuracy vs. Dictionary size

Apparently, the dictionary size is a very important parameter because it highly affects the overall performance. For the Labmade dataset, the highest score was achieved by using a relatively large dictionary of 2000 centers. It is worth noting that after 1000 centers the accuracy is getting marginally better. Therefore, anything over 2000 is expected to increase performance cost rather than the accuracy.

TABLE IX. DATA SET= ICDAR 2013, *K*=2000, *WINDOW* = *MAIN BODY* , SVM *C* PARAMETER = 0.0001

ICDAR 2013		Predicted Class: Greek	English	Indian
Actual Class	Greek	0.86	0.12	0.02
	English	0.14	0.84	0.02
	Indian	0.04	0.02	0.94
Mean Diagonal Accuracy : 88%				

Similarly, on the ICDAR 2013 dataset the best results obtained for window size = *main body x 1* and *k=2000* (table 9).

Regarding ICDAR2013 dataset, the best performance for the Bag Of Visual Features model is a bit lower than the best result of the labmade dataset, since this dataset is much harder as it contains only handwritten documents images.

B. *The Fisher Vector System*

For this approach, the optimal dictionary size among our experiments on the ICDAR dataset proved to be 256 elements (tables 10-12, Fig.11), since for more elements the whole system gets very slow and eventually it runs out of memory. Similarly, in [20] they also suggest a codebook of 256 clusters. Again, the window of size=*main body x 1* was used. Finally, in table 13, the results for the Labmade dataset are given.

TABLE X. DATA SET= ICDAR2013, *K*=64, *WINDOW* = *MAIN BODY X 1*, SVM *C* PARAMETER = 0.0001

ICDAR 2013		Predicted Class: Greek	English	Indian
Actual Class	Greek	86	10	4
	English	12	86	2
	Indian	2	0	98
Mean Diagonal Accuracy : 90%				

TABLE XI. DATA SET= ICDAR2013, K=128, WINDOW = MAIN BODY X 1, SVM C PARAMETER = 0.0001

ICDAR 2013		Predicted Class: Greek	English	Indian
Actual Class	Greek	88	12	0
	English	8	92	0
	Indian	2	0	98
Mean Diagonal Accuracy : 92.66%				

TABLE XII. DATA SET= ICDAR2013, K=256, WINDOW = MAIN BODY X 1, SVM C PARAMETER = 0.0001

ICDAR 2013		Predicted Class: Greek	Predicted Class: English	Predicted Class: Indian
Actual Class	Greek	0.92	0.08	0
	English	0.06	0.94	0
	Indian	0	0	1
Mean Diagonal Accuracy : 95,33%				

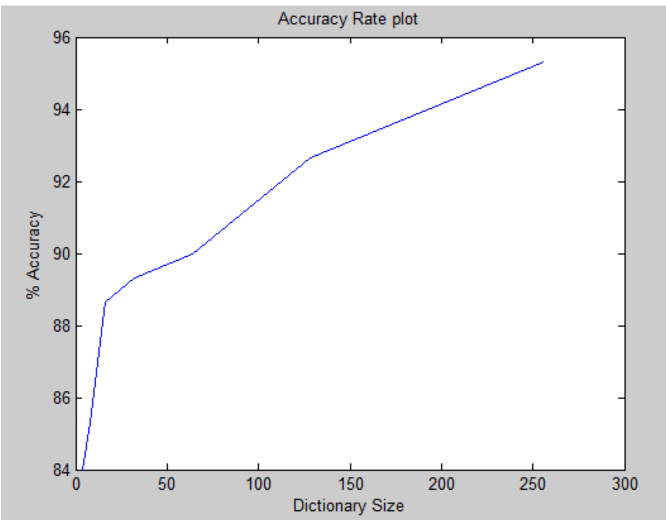

Fig. 11. Accuracy vs. Dictionary size

TABLE XIII. DATA SET= LABMADE, *K*=256, *WINDOW = MAIN BODY X 1*, SVM *C* PARAMETER = 0.0001

Labmade		Predicted Class: Greek	Predicted Class: English	Predicted Class: Arabic
Actual Class	Greek	0.925	0.05	0.025
	English	0.025	0.95	0.025
	Arabic	0.025	0	0.975
Mean Diagonal Accuracy : 95%				

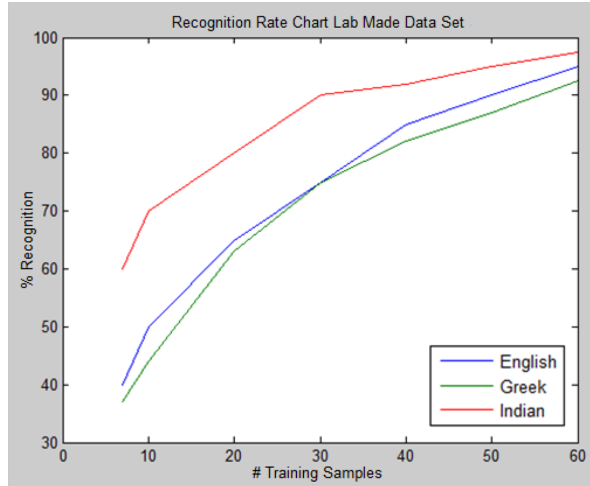

Fig. 12. Recognition Rate for the Labmade dataset

These results are quite surprising since they give higher scores in ICDAR 2013 dataset, which is objectively a harder handwritten dataset compared to the Labmade. However, by a closer look on the data in the labmade results, the scores regarding the Greek and English documents are slightly higher than their handwritten equivalent ones (Fig.12-13).

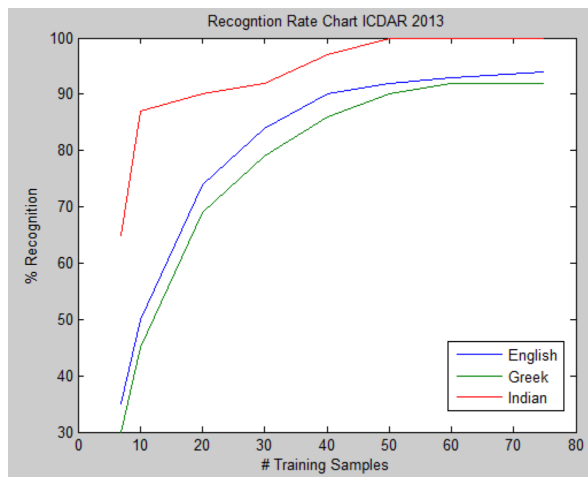

Fig. 13. Recognition Rate for the ICDAR 2013

This proves that languages with very distinctive features like Arabic and Indian are much easier to separate. Even with a small amount of training samples it is enough to obtain acceptable recognition rates.

It was mentioned that the dimensionality of a Fisher Vector representation is given by the formula $K(2D+1)$, where K is the number of GMM clusters and D the local image descriptor dimensions. Suppose that we have formed a GMM dictionary of $K=256$ centers like above. As the SIFT descriptor is 128-

dimensional, every image is represented by a vector of 256▪(2▪128+1), or 65792 elements. A good idea to shrink the Fisher vector is the application of PCA to the 128-D SIFT descriptors [20]. This would lead to a more computationally efficient classification scheme as the SVM would have to deal with smaller Fisher Vectors. In [21], they propose to apply PCA on SIFT descriptors to reduce their dimension from 128 to 64. This would cut down the final Fisher Vector to 33024 elements instead of 65792, which makes the system much more efficient and less memory starving. In [20] they report some increase in their overall classification performance after applying PCA, about 4%. In of our system, regarding the effect of PCA, apart of the faster computation and less memory demands, the overall performance was slightly dropped (Fig.14).

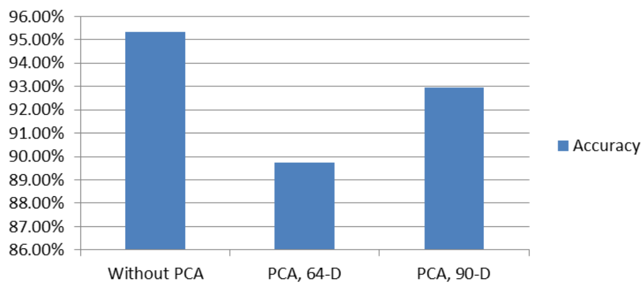

Fig. 14. Considering PCA for the proposed system

In any case, the reported results were already pretty high, so it was quite expected that PCA wouldn't help drastically. In fact, it didn't help at all. This also could mean that the extracted features are of high quality and very discriminative and contain very small amounts of redundant data, if any at all.

C. Comparative results

In this section, comparative results to the system presented in [6] are given.

Maryland + IAM 3.0	Predicted Class (Percentages)							
Actual Class	Thai	Cyrillic	Chinese	Hindi	Korean	Japanese	Arabic	English
Thai	100	0	0	0	0	0	0	0
Cyrillic	0	97.5	0	0	0	0	2.5	0
Chinese	0	0	97.5	0	2.5	0	0	0
Hindi	0	0	2.5	97.5	0	0	0	0
Korean	0	0	0	0	100	0	0	0
Japanese	0	0	6.65	0	0	66.7	26.65	0
Arabic	0	0	0	0	8.70	0	91.30	0
English	0	1	0	0	0	0	0.5	98.5
Mean Diagonal Accuracy : 93.62%								

Fig. 15. Confusion matrix for the BoFV system

Maryland + IAM 3.0	Predicted Class (Percentages)							
Actual Class	Thai	Cyrillic	Chinese	Hindi	Korean	Japanese	Arabic	English
Thai	100	0	0	0	0	0	0	0
Cyrillic	0	100	0	0	0	0	0	0
Chinese	0	0	97.5	0	2.5	0	0	0
Hindi	0	0	0	100	0	0	0	0
Korean	0	0	0	0	100	0	0	0
Japanese	0	0	0	0	0	80	20	0
Arabic	0	0	0	0	0	0	100	0
English	0	0	0	0	0	0	0	100
Mean Diagonal Accuracy : 97.18%								

Fig. 16. Confusion matrix for the FV system

Maryland + IAM 3.0	Predicted Class (Percentages)							
Actual Class	Thai	Cyrillic	Chinese	Hindi	Korean	Japanese	Arabic	English
Thai	96.3	0	0.3	0.9	0.3	0.6	0	1.6
Cyrillic	0.4	97.1	0	0	0	0	0.5	2
Chinese	0.2	0.7	85	1	1	6.7	1.4	4
Hindi	0	0	0.2	98.8	0	0.8	0.2	0
Korean	0.1	0.5	0.8	1.9	96	0.5	0	0.1
Japanese	0	0	1.3	0.2	1.3	96.2	0	1
Arabic	0	0	0.3	0	0	0	99.7	0
English	0.6	0.6	0	0.2	1.1	0	1.6	95.9
Mean Diagonal Accuracy : 95.6%								

Fig. 17. Confusion matrix for the system in [6]

To evaluate objectively the proposed systems, they are compared to the current state of the art system presented by G. Zhu et al. in [6] by using the same databases; The IAM handwriting DB3.0 database [22] as well as the University of Maryland multilingual database [23]. The dataset contains over 1000 document images from both databases in 8 languages (Thai, Cyrillic, Chinese, Hindi, Korean, Japanese, Arabic and English). The comparative results are given (Fig.15-17) in the form of confusion tables.

V. Conclusions

In this paper, two systems for the task of Language Identification based on document Images have been proposed. To evaluate the performance of the proposed systems, three datasets were used. From the experimental results, it is concluded that both of these systems have high potential, although the Fisher Vector approach proved to be much better and more accurate than the Bag of Visual Features. It is also safe to claim that the Fisher Vector method is able to outperform the current state of the art approach for the task of Language Identification as it is shown in section 4.3.

The main advantages of the Fisher Vector (FV) image representation over Bag of Visual Features (BoVF) representation, is, that the former, using a much smaller dictionary, that contains only 256 clusters, it significantly outperforms the BoVF system which needs at least a 1000-words dictionary to perform well, as it was proved in our experiments. Therefore, the FV system has a lower computational cost as it requires a much smaller dictionary to obtain acceptable recognition accuracy. The only issue with Fisher vectors is that they are quite dense compared to the sparse BoVF histograms, which makes them unappealing, in case we have to deal with a lot of data, as the storage and I/O requirements will increase dramatically.

Another very important fact is that even with a small number of training samples, it can perform exceptionally well, especially if the document language includes very distinctive features.

Finally, the choice to include a preprocessing task like the main body estimation is of high importance. This task helped to extract very distinctive, personalized and relevant features from every image and increased the overall accuracy of our system.

In the future, we are going to experiment with more techniques inspired from Natural Language Processing for the document Image Processing tasks.

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Analytical Study of Some Selected Classification Algorithms in WEKA Using Real Crime Data

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Abstract—**Data mining in the field of computer science is an answered prayer to the demand of this digital age. It is used to unravel hidden information from large volumes of data usually kept in data repositories to help improve management decision making. Classification is an essential task in data mining which is used to predict unknown class labels. It has been applied in the classification of different types of data. There are different techniques that can be applied in building a classification model. In this study the performance of these techniques such as J48 which is a type of decision tree classifier, Naïve Bayesian is a classifier that applies probability functions and ZeroR is a rule induction classifier are used. These classifiers are tested using real crime data collected from Nigeria Prisons Service. The metrics used to measure the performance of each classifier include accuracy, time, True Positive Rate (TP) Rate, False Positive (FP) Rate, Kappa Statistic, Precision and Recall. The study showed that the J48 classifier has the highest accuracy compared to other two classifiers in consideration. Choosing the right classifier for data mining task will help increase the mining accuracy.**

Keywords—Data Mining; Classification; Decision Tree; Naïve Bayesian; Tp Rate; component; formatting

I. INTRODUCTION

In this era of digital age and with the improvement in computer technology, many organizations usually gather large volumes of data from operational activities and after which are left to waste in data repositories. That is why [1] in his book said that we are drowning in data but lack relevant information for proactive management decision. Any tool that will help in the analysis of these large volumes of data that is being generated daily by many organizations is an answered prayer. It was this demand of our present digital age that gave birth to the field of data mining in computer science [2].

Data Mining is all about the analysis of large amount of data usually found in data repositories in many organizations. Its application is growing in leaps and bounds and has touched every aspect of human life ranging from science, engineering to business applications [3]. Data mining can handle different kinds of data ranging from ordinary text and numeric data to image and voice data. It is a multidisciplinary field that has applied techniques from other fields especially statistics, database management, machine learning and artificial intelligence [3].

With the aid of improved technology in recent years, large volumes of data are usually accumulated by many organizations and such data are usually left to waste in various data repositories. With the help of data mining such data can now be mined using different mining methods such as clustering, classification, association and outlier detection method in order to unravel hidden information that can help in improved decision making process [4].

Crime is a social sin that affects our society badly in recent times. Thus, to control this social sin, it is needful to put in place effective crime preventive strategies and policies by analyzing crime data for better understanding of crime pattern and individuals involved in crime using data mining techniques. Understanding the capability of various methods with regards to the analysis of crime data for better result is crucial. Classification is the data mining technique of focus in this paper. The performance of some selected classifiers such as J48, zeroR and Naïve Bayes are studied based on metrics such as accuracy, True Positive (TP) Rate, False Positive (FP) Rate, Kappa statistics, precision, recall and time taken to build the classification models.

The rest of the sections are discussions on the classifiers and their performance analysis with real crime data collected from the Nigeria Prisons Service in 2014.

II. CLASSIFICATION

Classification is the act of looking for a model that describes a class label in such a way that such a model can be used to predict an unknown class label [3]. Thus, classification is usually used to predict an unknown class labels. For instance, a classification model can be used to classify bank loans as either safe or unsafe. Classification applies some methods like decision tree, Bayesian method and rule induction in building its models. Classification process involves two steps. The first step is the learning stage which involves building the models while the second stage involves using the model to predict the class labels.

A record E with $n-\text{attributes}$ can be represented as $E = (e_1, e_2, \ldots e_n)$ each of the records E belongs to a class of attributes $(A_1, A_2, \ldots A_n)$. An attribute with discrete value is termed categorical or nominal attribute and this is normally referred to as class labels. The set of records that are used to build classification models are usually referred to as training records. The model can be represented as a function Y = F(e) which denotes the attribute Y of a particular record E. This function can be represented as rules, decision trees or mathematical formulae.

III. Decision Tree

It is a well known classification method that takes the form of tree structure and it is usually made up of:

1) Testing node which holds the data for testing the condition

2) Start node is the parent and usually top most node.

3) Terminal node (leaf node): is the predicted class label

4) Branches: represents results of a test made on an attribute.

Figure 1: is a sample decision tree that predicts the purchasing interest of a customer in computer. Rectangular shapes are used for testing nodes while oval shapes are used for result nodes. It is mostly binary while others are non binary.

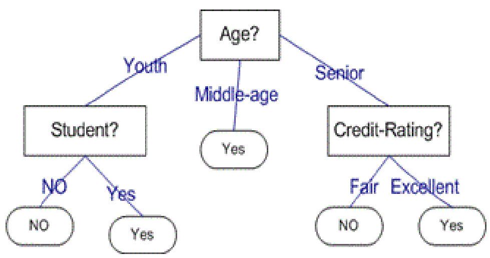

Fig. 1. A simple Decision Tree

Source: (Jiawei et al, 2011)

B. Building Decision Tree

Decision tree can be built using different methods, the first method developed was ID3 (Interactive, Dichotomiser) which later metamorphosed into C4.5 classifier. J48 classifier is an improved version of C4.5 decision tree classifier and has become a popular decision tree classifier. Classification and Regression Trees (CART) was later developed to handle binary trees. Thus, ID3, J48 and CART are basic methods of decision tree classification [5].

C. Decision Tree Algorithm

Algorithm
Parameters
Dataset T and its fields
Set of Attributes A
Selection Technique for the Attribute
Result
Tree Classifier
Procedure
1) A node is Created (call it E)
2) Check if all records R is in one group G and write node E as
the last node in the that Group G
3) If $A = 0$ (no attribute)
4) then write E as the last node
5) Use Selection technique for attributes on (R, A) to get the
Best splitting condition
6) Write the condition on node E
7) Check if attribute is discrete and allows multiway split then
It is not strictly binary tree
8) For all output O from splitting condition, divide the records and build the tree
9) Assign $R_0 = Set\ of\ all\ records\ in\ output\ O$
10) If $R_o = 0$ then
11) Node E is attached with a leaf labelled with majority class R
12) Otherwise node E is attached with node obtained from
Generate Decision Tree (R_o, A)
13) Next
14) Write E

Fig. 2. Decision Tree Algorithm

Source: (jiawei, et al, 2011)

IV. Naïve Bayesian

This is a classification method that is based on Bayes' theorem which is used to predict class labels. This classifier is based on probability theorem and is named after Thomas Bayes who is the founder of the theorem [6].

Suppose R is a record set, it is considered as evidence in Bayesian theorem and R depends on n-features. Assume rule T implies that R ∈ K class, the condition that T is true if R ∈ K is given by P(T ∩ R).

For example, suppose a dataset R is described by age and educational qualification and R is a person within the age of 20 - 34 and has no educational qualification and T is a rule that someone within that particular age limit and educational qualification is likely to commit an offense then P(T ∩ R) implies that someone is likely to commit an offense if its age and educational qualification is within the limit.

P(T) is a general probability which implies that anyone is likely to commit offense not minding the age and educational qualification and other things that might be considered thus P(T) is not dependent on R. In order words, P(T ∩ R) is the probability of R when satisfied rule T. That is to say that a person is likely to commit an offense if the age and educational qualification is within the rule. P(R) is the probability that someone from the given dataset is within the age limit and a given educational qualification level. Bayes' theorem is given as in equation 1.

$$P(T \cap R) = \frac{P(R \cap T)P(T)}{P(R)}, \text{ provided } P(R) > 0 \qquad (1)$$

V. Zeror Classifier

It is a rule based method for data classification in WEKA. The rule usually considers the majority of training dataset as real Zero R prediction. Thus, it focuses on targeted class labels and ignores others. Zero R is not easily predictable; it only serves as a baseline for other classifiers [7].

VI. About Weka

It is machine learning software developed at university of Waikato in New Zealand. It is an open source software and can be freely downloaded from this web site address http://www.cs.waikato.ac.nz. It accepts its data in ARFF (Attribute Related File Format). It has different algorithms for data mining and can work in any platform. The Graphical User Interface (GUI) is as shown in figure 3 [8].

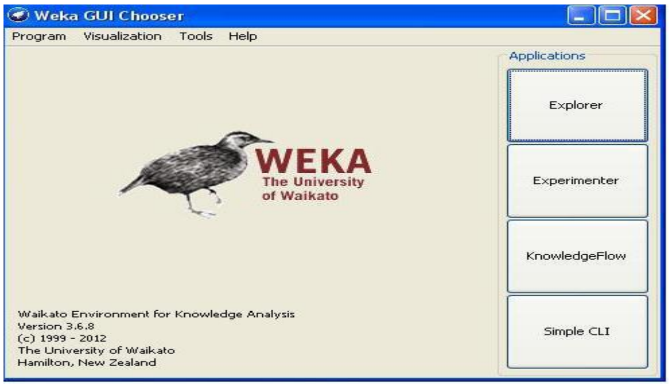

Fig. 3. WEKA GUI Chooser

VII. Experiments

A. Evaluation Metrics

The parameters considered while evaluating the selected classifiers are:

1) *Accuracy:* This shows the percentage of correctly classified instances in each classification model

2) *Kappa:* Measures the relationship between classified instances and true classes. It usually lies between [0, 1]. The value of 1 means perfect relationship while 0 means random guessing.

3) *TP Rate:* Is the statistics that shows correctly classified instances.

4) *FP Rate:* Is the report of instances incorrectly labelled as correct instances.

5) *Recall:* Measures the percentage of all relevant data that was returned by the classifier. A high recall means the model returns most of the relevant data.

6) *Precision:* Measures the exactness of the relevant data retrieved. High precision means the model returns more relevant data than irrelevant data.

7) *Time:* Time taken to perform the classification [9;10].

B. Datasets

A real crime data collected from selected prisons in Nigeria were used to perform this experiment. The dataset were converted to Attribute Related File Format (ARFF) form for easy processing by WEKA. The dataset was divided into two: training set and test set. The former was used to train the model while the other was used to test the built model. A cross validation process was applied in dividing the dataset into training and test set. The process divides the data into equal parts usually $k = 10$ and the model was trained using $k - 1$ fold and kth fold was used as test set. The process was repeated K times to allow for both training and testing of each set.

C. Testing of J48 Classifier on crime data

J48 classifier is an enhanced version of C4.5 decision tree classifier and has become a popular decision tree classifier. It builds its model using a tree structure which usually made up of the following:

1) Testing node which holds the data for testing the condition

2) Start node is the parent and usually top most of the node.

3) Terminal node (leaf node): is the predicted class label

4) Branches: represents results of a test made on an attribute.

```
=== Run information ===

Scheme:weka.classifiers.trees.J48 -C 0.25 -M 2
Relation:     Combined_Prisons
Instances:    1733
Attributes:   4
              Offence
              Age
              Edu-Qualification
              Occupation

Time taken to build model: 0.76 seconds

=== Stratified cross-validation ===
=== Summary ===

Correctly Classified Instances       1025          59.146 %
Incorrectly Classified Instances      708          40.854 %
Kappa statistic                         0.1516
Mean absolute error                     0.2769
Root mean squared error                 0.3783
Relative absolute error                93.9487 %
Root relative squared error            98.5845 %
Total Number of Instances            1733

=== Detailed Accuracy By Class ===

TP Rate  FP Rate  Precision  Recall  F-Measure  ROC Area  Class
0.266    0.09     0.515      0.266   0.351      0.627     Secondary
0        0.003    0          0       0          0.663     Tertiary
0.022    0.013    0.2        0.022   0.04       0.586     Primary
0.913    0.758    0.613      0.913   0.733      0.61      NONE
0.591    0.456    0.51       0.591   0.514      0.613     Weighted Avg

=== Confusion Matrix ===

   a   b   c   d   <-- classified as
 122   2  10 324 |   a = Secondary
  10   0   2  51 |   b = Tertiary
  30   0   5 193 |   c = Primary
  75   3   8 898 |   d = NONE
```

Fig. 4. Run information for J48 classifier

D. Naïve Bayes Classifier evaluation on Crime data

```
=== Run information ===

Scheme:weka.classifiers.bayes.NaiveBayes
Relation:     Combined_Prisons
Instances:    1733
Attributes:   4
              Offence
              Age
              Edu-Qualification
              Occupation
Test mode:10-fold cross-validation

=== Classifier model (full training set) ===

Naive Bayes Classifier


Time taken to build model: 0.09 seconds

=== Stratified cross-validation ===
=== Summary ===

Correctly Classified Instances         984               56.7802 %
Incorrectly Classified Instances       749               43.2198 %
Kappa statistic                          0.0813
Mean absolute error                      0.279
Root mean squared error                  0.3771
Relative absolute error                 94.6346 %
Root relative squared error             98.2499 %
Total Number of Instances             1733

=== Detailed Accuracy By Class ===

TP Rate   FP Rate   Precision   Recall  F-Measure   ROC Area  Class
0.157     0.077      0.424     0.157     0.229      0.643    Secondary
0         0.002      0         0         0          0.709    Tertiary
0.031     0.015      0.233     0.031     0.054      0.612    Primary
0.92      0.834      0.592     0.92      0.72       0.634    NONE
0.568     0.496      0.478     0.568     0.477      0.636 Weighted Avg

=== Confusion Matrix ===

   a   b   c   d   <-- classified as
  72   0  10 376 |   a = Secondary
   7   0   2  54 |   b = Tertiary
  24   2   7 195 |   c = Primary
  67   1  11 905 |   d = NONE
```

Fig. 5. Run Information for Naïve Bayes Classifier

E. ZeroR Classifier Evaluation

It is a simple classification method that works with mode for the prediction of nominal data and mean for the prediction of numeric data. It is usually referred to as majority class method.

```
=== Run information ===

Scheme:weka.classifiers.rules.ZeroR
Relation:     Combined_Prisons
Instances:    1733
Attributes:   4
              Offence
              Age
              Edu-Qualification
              Occupation
Test mode:10-fold cross-validation

=== Classifier model (full training set) ===

ZeroR predicts class value: NONE

Time taken to build model: 0.09 seconds

=== Stratified cross-validation ===
=== Summary ===

Correctly Classified Instances         984               56.7802 %
Incorrectly Classified Instances       749               43.2198 %
Kappa statistic                          0
Mean absolute error                      0.2948
Root mean squared error                  0.3838
Relative absolute error                100      %
Root relative squared error            100      %
Total Number of Instances             1733

=== Detailed Accuracy By Class ===

TP Rate   FP Rate   Precision   Recall  F-Measure   ROC Area  Class
0         0          0          0         0          0.497    Secondary
0         0          0          0         0          0.483    Tertiary
0         0          0          0         0          0.495    Primary
1         1          0.568      1         0.724      0.498     NONE
0.568     0.568      0.322      0.568     0.411      0.497 Weighted Avg

=== Confusion Matrix ===

   a   b   c   d   <-- classified as
   0   0   0 458 |   a = Secondary
   0   0   0  63 |   b = Tertiary
   0   0   0 228 |   c = Primary
   0   0   0 984 |   d = NONE
```

Fig. 6. Run Information for ZeroR

VIII. Result Discussion

Table 1 shows the tabulation of various results obtained from the three classifier used in this work while figure 7 is the graphical representation of the results.

TABLE I. TABULATED RESULT

Evaluation Metrics	J48	Naïve Bayes	ZeroR
Time	0.76 Secs	0.09 Secs	0.09 Secs
Accuracy	59.15%	56.78%	56.78%
`TP Rate	0.591	0.568	0.568
FP Rate	0.456	0.496	0.568
Kappa	0.15	0.0813	0
Precision	0.51	0.478	0.322
Recall	0.591	0.568	0.568

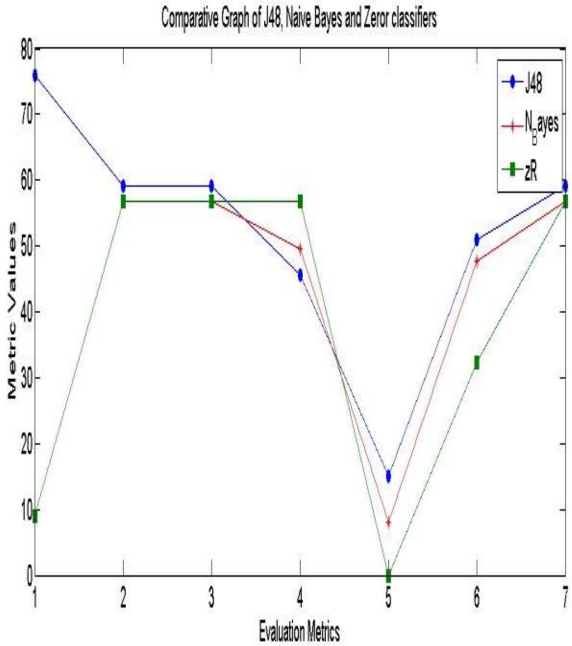

Fig. 7. Graph of the three Classifiers

The study shows that the J48 classifier has higher accuracy of 59.15 while both Naïve Bayesian and ZeroR classifier has accuracy of 56.78 each. The J48 though took more time of 0.76 seconds to build the model compare to 0.09 seconds each for both Naïve Bayesian and ZeorR classifier, where time is not the main metric for evaluation of the performance, the j48 classifier can be said to have performed better than Naïve Bayesian and ZeroR classifiers.

IX. CONCLUSION

The advancement in data mining has been accompanied with development of various mining techniques and algorithms. Choosing the right technique for a particular type of data mining task is now becoming difficult. The best way is to perform a particular task using different techniques in order to choose the one that gives the best result. This work performed a comparative analysis of three classification techniques J48, Naïve Bayesian and zeroR to see which one that will give the best result using real crime data collected from some selected Nigerian prisons. There by proposing a frame work for choosing a better algorithm for data mining tasks. The J48 seems to have performed better than Naïve Bayesian and ZeroR classifiers using crime dataset and thus can be recommended for the classification of crime data. However, further work can be carried out using a different dataset and other classification techniques in WEKA mining tool or any other mining tool.

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Differential Evolution Enhanced with Eager Random Search for Solving Real-Parameter Optimization Problems

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***Abstract*—Differential evolution (DE) presents a class of evolutionary computing techniques that appear effective to handle real parameter optimization tasks in many practical applications. However, the performance of DE is not always perfect to ensure fast convergence to the global optimum. It can easily get stagnation resulting in low precision of acquired results or even failure. This paper proposes a new memetic DE algorithm by incorporating Eager Random Search (ERS) to enhance the performance of a basic DE algorithm. ERS is a local search method that is eager to replace the current solution by a better candidate in the neighborhood. Three concrete local search strategies for ERS are further introduced and discussed, leading to variants of the proposed memetic DE algorithm. In addition, only a small subset of randomly selected variables is used in each step of the local search for randomly deciding the next trial solution. The results of tests on a set of benchmark problems have demonstrated that the hybridization of DE with Eager Random Search can substantially augment DE algorithms to find better or more precise solutions while not requiring extra computing resources.**

Keywords*—Evolutionary Algorithm, Differential Evolution, Eager Random Search, Memetic Algorithm, Optimization

I. Introduction

Evolutionary algorithms (EAs) are stochastic and biologically inspired techniques that provide powerful and robust means to solve many real-world optimization problems. They are population-based optimization approaches [1] which perform parallel and beam search, thereby exhibiting strong global search ability in complex and high dimensional spaces. Another merit of EAs is that they dont need the derivative information of objective functions. This is very attractive for wide applications of EAs in various situations without requiring the problem space to be continuous and differentiable. Many variants of EAs have been developed to deal with real-parameter continuous optimization problems, including evolution strategies [2], real-coded genetic algorithms [3], [4], differential evolution (DE) [5], [6], and particle swarm optimization [7] and [8].

Differential evolution presents a class of evolutionary techniques to solve real parameter optimization tasks with nonlinear and multimodal objective functions. Despite sharing common concepts of EAs, DE differs from many other EAs in that mutation in DE is based on differences of pair(s) of individuals randomly selected from the population. Thus, the direction and magnitude of the search is decided by the distribution of solutions instead of a pre-specified probability density function. DE has been used as very competitive alternative in many practical applications due to its simple and compact structure, easy use with fewer control parameters, as well as high convergence in large problem spaces. However, the performance of DE is not always excellent to ensure fast convergence to the global optimum. It can easily get stagnation resulting in low precision of acquired results or even failure [9].

Recent researches have shown that hybridization of EAs with other techniques such as metaheuristics or local search techniques can greatly improve the efficiency of the search. EAs that are augmented with local search for self-refinement are called Memetic Algorithms (MAs) [[10], [11]]. In MAs, a local search mechanism is applied to members of the population in order to exploit the most promising regions gathered from global sampling done in the evolutionary process. Memetic computing has been used with DE to refine individuals in their neighborhood. Norman and Iba [12] proposed a crossover-based adaptive method to generate offspring in the vicinity of parents. Many other works apply local search mechanisms to certain individuals of every generation to obtain possibly even better solutions, see examples in ([13], [14], [15], [16]), [17]).

This paper proposes a new memetic DE algorithm by incorporating Eager Random Search (ERS) to enhance the performance of a conventional DE algorithm. ERS is a local search method that is eager to move to a position that is identified as better than the current one without considering other opportunities in the neighborhood. This is different from common local search methods such as gradient descent [18] or hill climbing [19] which seek local optimal actions during the search. Forsaking optimality of moves in ERS is advantageous to increase randomness and diversity of search for avoiding premature convergence. Three concrete local search strategies within ERS are introduced and discussed, leading to variants of the proposed memetic DE algorithm. In addition, only a small subset of randomly selected variables is used in every step of the local search for randomly deciding the next trial point. The results of tests on a set of benchmark problems have demonstrated that the hybridization of DE with

Eager Random Search can bring improvement of performance compared to pure DE algorithms while not incurring extra computing expenses.

The rest of the paper is organized as follows. Section 2 briefly presents the related works. Section 3 introduces the basic DE algorithm. Then, the proposed memetic DE algorithm in combination with Eager Random Search is presented in details in Section 4. Section 5 gives the results of tests for evaluation. Finally, concluding remarks are given in Section 6.

II. Related Work

Since the first proposal of DE in 1997 [20], a lot of works have been done to improve the search ability of this algorithm, resulting in many variants of DE. A brief overview on some of them is given in this section.

Ali, Pant and Nagar [13] proposed two different local search algorithms, namely Trigonometric Local Search and Interpolated Local Search, which were applied to refine the best solution and two random solutions in every generation respectively.

Local search differential evolution was developed in [14] where a new local search operator was used on every individual in the population with a probability. The search strategy attempted to find a random better solution between trial vector and the best solution in the generation.

Dai, Zhou, Zhang and Jiang [15] combined Orthogonal Local Search with DE in the so-called OLSDE (Orthogonal Local Search Differential Evolution) algorithm. Therein two individuals were randomly selected from the population in each generation and they were used to generate a group of trial solutions with the orthogonal method. Then the best solution from the group of trial solutions replaced the worst individual in the population.

Jia, Zheng and Khan [9] proposed a memetic DE algorithm in combination with chaotic local search (CLS). The adaptive shrinking strategy embedded within CLS enabled the DE optimizer to explore large space in the early search phase and to exploit small regions in the later phase. Moreover, the chaotic iteration produced a higher probability to move into a boundary field, which appeared helpful for avoiding premature convergence to some extent. A similar work of utilizing chaotic principle based local search in DE was presented in [21].

Poikolainen and Neri [22] proposed a DE algorithm employing concurrent fitness based local search (DEcfbLS). The local search was applied to multiple promising solutions in the population, and the selection of individuals for local improvement was based on a fitness-based adaptation rule. Further, the local search operator was realized by making trial moves successively on single dimensions. But there was not much variation in the step sizes of the moves for different variables within an iteration of the search.

III. Basic DE

DE is a stochastic and population based algorithm with Np individuals in the population. Every individual in the population stands for a possible solution to the problem. One of the Np individuals is represented by $X_{i,g}$ with $i = 1, 2, ., N_p$ and g is the index of the generation. DE has three consecutive steps in every iteration: mutation, recombination and selection. The explanation of these steps is given below:

MUTATION. N_p mutated individuals are generated using some individuals of the population. The vector for the mutated solution is called mutant vector and it is represented by $V_{i,g}$. There are some ways to mutate the current population, but only three will be explained in this paper. The notation to name them is $DE/x/y/z$, where x stands for the vector to be mutated, y represents the number of difference vectors used in the mutation and z stands for the crossover used in the algorithm. We will not include z in the notation because only the binomial crossover method is used here. The three mutation strategies (random, current to best and current to rand) will be explained below. The other mutation strategies and their performance are given in [23].

- Random Mutation Strategy:

Random mutation strategy attempts to mutate three individual in the population. When only one difference vector is employed in mutation, the approach is represented by DE/rand/1. A new, mutated vector is created according to Eq. 1

$$V_{i,g} = X_{r_1,g} + F \times (X_{r_2,g} - X_{r_3,g}) \tag{1}$$

where $V_{i,g}$ represents the mutant vector, i stands for the index of the vector, g stands for the generation, $r_1, r_2, r_3 \in \{$ 1,2,. . . ,$N_p\}$ are random integers and F is the scaling factor in the interval [0, 2].

Fig. 1 shows how this mutation strategy works. All the variables in the figure appear in Eq. 1 with the same meaning, and d is the difference vector between $X_{r_2,g}$ and $X_{r_3,g}$.

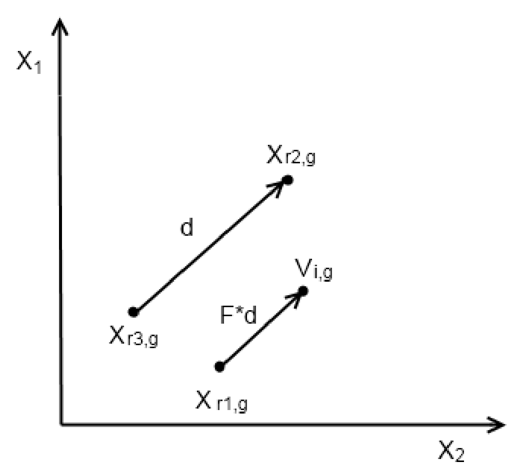

Fig. 1: Random mutation strategy

- Current to Best Mutation Strategy:

The current to best mutation strategy is referred as DE/current-to-best/1. It moves the current individual towards the best individual in the population before being disturbed with a scaled difference of two randomly selected vectors. Hence the mutant vector is created by

$$V_{i,g} = X_{i,g}+F1\times(X_{best,g}-X_{i,g})+F2\times(X_{r_1,g}-X_{r_2,g}) \quad (2)$$

where $V_{i,g}$ stands for the mutant vector, $X_{i,g}$ and $X_{best,g}$ represent the current individual and the best individual in the population respectively, $F1$ and $F2$ are the scaling factors in the interval [0, 2] and $r_1, r_2 \in \{$ 1,2,...,$N_p\}$ are randomly created integers.

Fig. 2 shows how the DE/current-to-best/1 strategy works to produce a mutant vector, where $d1$ denotes the difference vector between the current individual $X_{i,g}$, and $X_{best,g}$, $d2$ is the difference vector between $X_{r_1,g}$ and $X_{r_2,g}$.

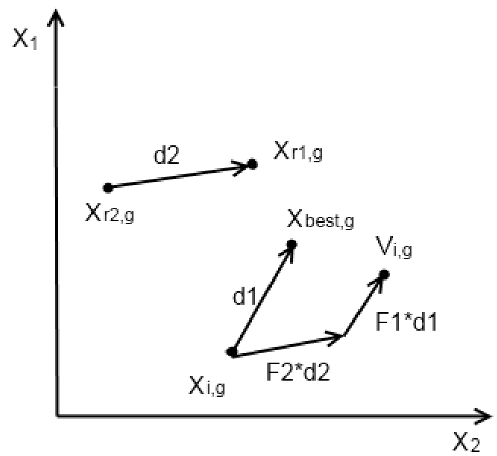

Fig. 2: Current to best mutation strategy

- Current to Rand Mutation Strategy:

The current to rand mutation strategy is referred to as DE/current-to-rand/1. It moves the current individual towards a random vector before being disturbed with a scaled difference of two randomly selected individuals. Thus the mutant vector is created according to Eq. 3 as follows

$$V_{i,g} = X_{i,g}+F1\times(X_{r_1,g}-X_{i,g})+F2\times(X_{r_2,g}-X_{r_3,g}) \quad (3)$$

where $X_{i,g}$ represents the current individual, $V_{i,g}$ stands for the mutant vector, g stands for the generation, i is the index of the vector, $F1$ and $F2$ are the scaling factors in the interval [0, 2] and $r1, r2, r3 \in \{$ 1,2,...,$N_p\}$ are randomly created integers.

Fig. 3 explains how the DE/current-to-rand/1 strategy works to produce a mutant vector, where $d1$ is the difference vector between the current individual, $X_{i,g}$, and $X_{r_1,g}$, and $d2$ is the difference vector between $X_{r_3,g}$ and $X_{r_2,g}$.

CROSSOVER. In step two we recombine the set of mutated solutions created in step 1 (mutation) with the original population members to produce trial solutions. A new trial vector is denoted by $T_{i,g}$ where i is the index and g is the generation.

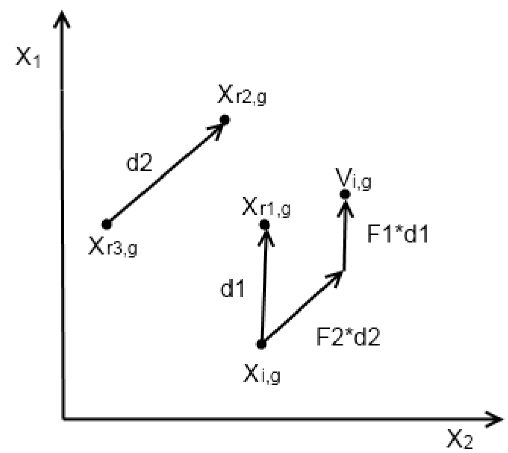

Fig. 3: Current to rand mutation strategy

Every parameter in the trial vector is calculated with equation 3

$$T_{i,g}[j] = \begin{cases} V_{i,g}[j] & \text{if } rand[0,1] < CR \text{ or } \quad j = j_{rand} \\ X_{i,g}[j] & \text{otherwise} \end{cases} \quad (4)$$

where j stands for the index of every parameter in a vector, CR is the probability of the recombination and j_{rand} is a randomly selected integer in $[1, N_p]$ to ensure that at least one parameter from the mutant vector is selected.

SELECTION. In this last step we compare a trial vector with its parent in the population with the same index i to choose the stronger one to enter the next generation Therefore, if the problem to solve is a minimization problem, the next generation is created according to equation 4

$$X_{i,g+1} = \begin{cases} T_{i,g} & \text{if } f(T_{i,g}) < f(X_{i,g}) \\ X_{i,g} & \text{otherwise} \end{cases} \quad (5)$$

where $X_{i,g}$ is an individual in the population, $X_{i,g+1}$ is the individual in the next generation, $T_{i,g}$ is the trial vector, $f(T_{i,g})$ stands for the fitness value of trial solution and $f(X_{i,g})$ is the fitness value of the individual in the population.

The pseudocode for basic DE is given in Alg. 1. First of all we create the initial population with randomly generated individuals. Then we evaluate every individual in the population with a fitness function. Afterward we perform the three main steps: mutation, recombination and selection. First we mutate the population according Eq. 1, Eq. 2 or Eq. 3, then we recombine mutant vectors and their parents to get trial vectors according to Eq. 4, which are also called offspring. Finally we compare the offspring with their parents and the better individuals get into the updated population. From step 3 to step 7 we need to repeat it until the termination condition is satisfied.

Algorithm 1 Differential Evolution

Initialize the population with ramdomly created individuals
Calculate the fitness values of all individuals in the population
while The termination condition is not satisfied **do**
  Create mutant vectors using a mutation strategy in Eq. 1, Eq. 2 or Eq. 3
  Create trial vectors by recombining mutant vectors with parents vector according to Eq. 4
  Evaluate trial vectors with their fitness function
  Select winning vectors according to Eq. 5 as individuals in the next generation
end while

IV. DE INTEGRATED WITH ERS

This section is devoted to the proposal of the memetic DE algorithm with integrated ERS for local search. We will first introduce ERS as a general local search method together with its three concrete (search) strategies, and then we shall outline how ERS can be incorporated into DE to enable self-refinement of individuals inside a DE process.

A. Eager Random Local Search (ERS)

The main idea of ERS is to immediately move to a randomly created new position in the neighborhood without considering other opportunities as long as this new position receives a better fitness score than the current position. This is different from some other conventional local search methods such as Hill Climbing in which the next move is always to the best position in the surroundings. Forsaking optimality of moves in ERS is beneficial to achieve more randomness and diversity of search for avoiding local optima. Further, in exploiting the neighborhood, only a small subset of randomly selected variables undergoes changes to randomly create a trial solution. If this trial solution is better, it simply replaces the current one. Otherwise a new trial solution is generated with other randomly selected variables. This procedure is terminated when a given number of trial solutions have been created without finding improved ones. The formal procedure of ERS is given in Algorithm 2, where α denotes the portion of variables that are subject to local changes and M is the maximum number of times a trial solution can be created in order to find a better position than the current one.

Algorithm 2 Eager Random Local Search

1: Set i = 1;
2: **while** $i <= M$ **do**
3:   $candidates$ = 1,2,. . . ,dimension;
4:   Set j = 1;
5:   **while** $j < \alpha * dimension$ **do**
6:     Randomly select k from candidates;
7:     Assign a random possible value to parameter k of the vector;
8:     Remove k from $candidates$;
9:     Set j = j + 1;
10:   **end while**
11:   **if** This new solution is better than the parent **then**
12:     Replace the parent solution with the new one;
13:     Set i = 1;
14:   **else**
15:     Set i = i + 1;
16:   **end if**
17: **end while**

The next more detailed issue with ERS is how to change a selected variable in making a trial solution in the neighborhood. This corresponds to the way to assign a possible value for parameter k in line 7 of Algorithm 2. Our idea is to solve this issue using a suitable probability function. We consider three probability distributions (uniform, normal, and Cauchy) as alternatives for usage when generating a new value for a selected parameter/variable. The use of different probability distributions lead to different local search strategies within the ERS family, which will be explained in the sequel.

1) Random Local Search (RLS): In Random Local Search (RLS), we simply use a uniform probability distribution when new trial solutions are created given a current solution. To be more specific, when dimension k is selected for change, the trial solution X' will get the following value on this dimension regardless of its initial value in the current solution:

$$X'[k] = rand(a_i, b_i) \tag{6}$$

where $rand(a_i, b_i)$ is a uniform random number between a_i and b_i , and a_i and b_i are the minimum and maximum values respectively on dimension k.

As equal chance is given to the whole range of a variable when changing a solution, RLS is more likely to create new points with large variation, thus increasing the opportunity to jump out from a local optimum. The disadvantage of RLS lies on its fine tuning ability to reach the exact optimum.

2) Normal Local Search (NLS): In Normal Local Search (NLS), we create a new trial solution by disturbing the current solution in terms of a normal probability distribution. This means that, if dimension k is selected for change, the value on this dimension for trial solution X' will be given by

$$X'[k] = X[k] + N(0, \delta) \tag{7}$$

where $N(0, \delta)$ represents a random number generated according to a normal density function with its mean being zero.

Owing to the use of the normal probability distribution, NLS usually creates new trial solutions that are quite close to the current one. This may, on one hand, bring benefit for the fine-tuning ability to reach the exact optimum. But, on the other hand, it will make it more difficult for the local search to escape from a local optimum.

3) Cauchy Local Search (CLS): In this third local search strategy, we apply the Cauchy density function in creating trial solutions in the neighborhood. It is called Cauchy Local search (CLS). A nice property of the Cauchy function is that it is centered around its mean value whereas exhibiting a wider distribution than the normal probability function, as is shown in Fig. 3. Hence CLS will have more chances to make big moves in attempts to find possibly better positions and to leave away from local minima. Regarding the fine-search ability, CLS will be better than RLS though it is not expected as good as NLS.

More concretely, a Cauchy probability density function is defined by

$$f(x) = \frac{1}{\pi} \times \frac{t}{t^2 + x^2}, t > 0 \quad (8)$$

Its corresponding cumulative probability function is given by

$$F(x) = \frac{1}{2} + \frac{1}{\pi} \times arctan(\frac{x}{t}) \quad (9)$$

It follows that, on a selected dimension k, the value of trial solution X' will be generated as follows:

$$X'[k] = X[k] + t \times tan(\pi \times (rand(0,1) - 0.5)) \quad (10)$$

where $rand(0,1)$ is a random uniform number between 0 and 1.

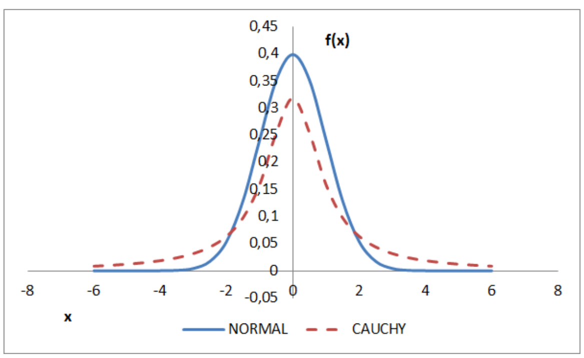

Fig. 4: Distribution probability

B. The Proposed Memetic DE Algorithm

Here with we propose a new memetic DE algorithm by combining basic DE with Eager Random Search (ERS). ERS is applied in each generation after completing the mutation, crossover and selection operators. The best individual in the population is used as the starting point when ERS is executed. If ERS terminates with a better solution, it is inserted into the population and the current best member in the population is discarded. The general procedure of the proposed memetic DE algorithm is outlined in Algorithm 3.

Finally, different strategies within ERS can be used for local search in line 9 of Algorithm 3. We use DERLS, DENLS, and DECLS to refer to the variants of the proposed memetic DE algorithm that adopt RLS, NLS, and CLS respectively as local search strategies.

Algorithm 3 Memetic Differential Evolution

1: Initialize the population with randomly created individuals
2: Calculate the fitness values of all individuals in the population
3: **while** The termination condition is not satisfied **do**
4: Create mutant vectors using a mutation strategy in Eq. 1, Eq. 2 or Eq. 3
5: Create trial vectors by recombining mutant vectors with parents vector according to Eq. 4
6: Evaluate trial vectors with their fitness function
7: Select winning vectors according to Eq. 5 as individuals in the next generation
8: Identify the best individual X_{best} in the population
9: Perform local search from X_{best} using a ERS strategy
10: **if** the result from local search X_r is better than X_{best} **then**
11: replace X_{best} by X_r in the population
12: **end if**
13: **end while**

V. Experiments and Results

To examine the merit our proposed memetic DE algorithm compared to basic DE, we tested the algorithms in thirteen benchmark functions [24] listed in Table 1. Functions 1 to 7 are unimodal and functions 8 to 13 are multimodal functions that contain many local optima. Table 1 gives the definition of every function. The most difficult functions are 8, 9 and 10, which are shown in Figs. 5, 6 and 7 respectively.

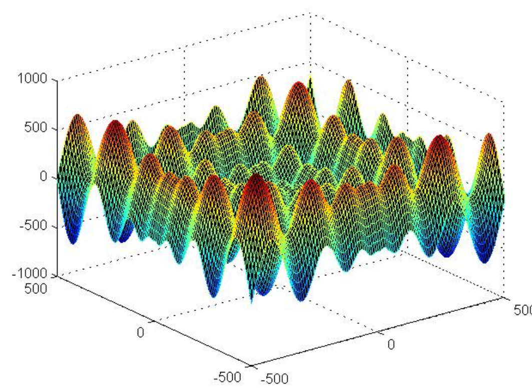

Fig. 5: Function 8 with two dimensions

A. Experimental Settings

DE has three main control parameters: population size (N_p), crossover rate (CR) and the scaling factor (F) for mutation. The following specification of these parameters was used in the experiments: $Np = 60$, $CR = 0.85$ and $F, F1, F2 = 0.9$. All the algorithms were applied to the benchmark problems with the aim to find the best solution for each of them. Every algorithm was executed 30 times on every function to acquire a fair result for the comparison. The condition to finish the execution of DE programs is that the error of the best result found is below 10e-8 with respect to the true minimum or the number of evaluations has exceeded

TABLE I: The thirteen functions used in the experiments

FUNCTION
f1(x) = $\sum_{i=1}^{n} x_i^2$
f2(x) = $\sum_{i=1}^{n} \lvert x_i \rvert + \prod_{i=1}^{n} \lvert x_i \rvert$
f3(x) = $\sum_{i=1}^{n} (\sum_{j=1}^{i} x_j)^2$
f4(x) = $max_i\{\lvert x_i \rvert, 1 \leq i \leq n\}$
f5(x) = $\sum_{i=1}^{n-1} [100 \times (x_{i+1} - x_i^2)^2 + (x_i - 1)^2]$
f6(x) = $\sum_{i=1}^{n} \lfloor (x_i + 0.5)^2 \rfloor$
f7(x) = $\sum_{i=1}^{n} i \times x_i^4 + random[0,1)$
f8(x) = $\sum_{i=1}^{n} -x_i \times sin(\sqrt{\lvert x_i \rvert})$
f9(x) = $\sum_{i=1}^{n} [x_i^2 - 10 \times cos(2 \times \pi \times x_i) + 10]$
f10(x) = $-20 \times exp(-0.2 \times \sqrt{\frac{1}{n} \times \sum_{i=1}^{n} x_i^2}) - exp(\frac{1}{n} \times \sum_{i=1}^{n} cos(2\pi x_i)) + 20 + e$
f11(x) = $\frac{1}{4000} \times \sum_{i=1}^{n} x_i^2 - \prod_{i=1}^{n} cos(\frac{x_i}{\sqrt{i}}) + 1$
f12(x) = $\frac{\pi}{n} \times \{10sin^2(\pi y_i) + \sum_{i=1}^{n-1} ((y_i - 1)^2 [1 + 10sin^2(\pi y_{i+1})]) + (y_n - 1)^2\} + \sum_{i=1}^{n} u(x_i, 10, 100, 4)$, where $y_i = 1 + \frac{1}{4}(x_i + 1)$; $u(x_i, a, k, m) = \begin{cases} k(x_i - a)^m, & x_i > a \\ 0, & -a \leq x_i \leq a \\ k(x_i - a)^m, & x_i < -a \end{cases}$
f13(x) = $0.1 \times \{sin^2(3\pi x_1) + \sum_{i=1}^{n-1} ((x_i - 1)^2 [1 + sin^2(3\pi x_{i+1})]) + (x_n - 1)[1 + sin(2\pi x_n)^2]\} + \sum_{i=1}^{n} u(x_i, 5, 100, 4)$

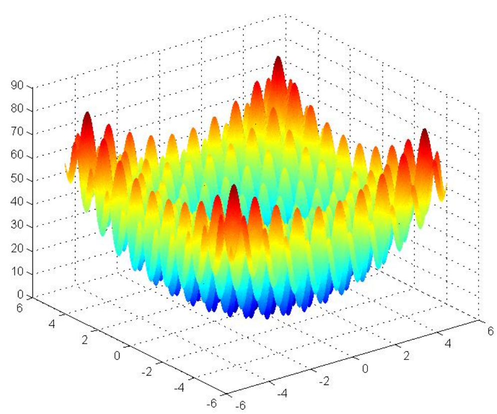

Fig. 6: Function 9 with two dimensions

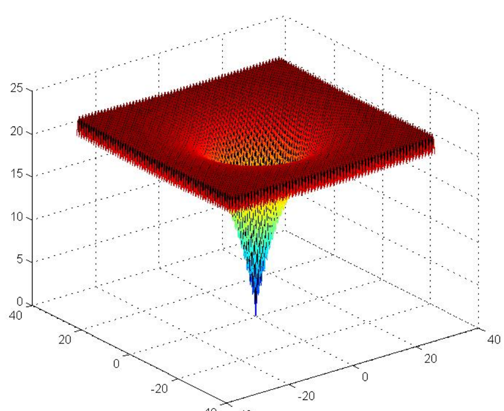

Fig. 7: Function 10 with two dimensions

300,000. The parameters in DECLS are $t = 0.2$, $M = 5$ and $\alpha = 0.1$.

The results of experiments will be presented as follows: First we will compare the performance (the quality of acquired solutions) of the various DE approaches with random mutation strategy, secondly we will compare the performance of the same approaches using the current to rand mutation strategy and third we will compare the performance of the same approaches using the current to best mutation strategy.

B. Performance of the Memetic DE with random mutation strategy

First, random mutation strategy (DE/rand/1) was used in all DE approaches to study the effect of the ERS local search strategies in the memetic DE algorithm. The results can be observed in Table 2 and the values in boldface represent the lowest average error found by the approaches.

In Table 3 there is a ranking among all the approaches for every function. The last row represents the average of the rankings.

We can see in Table 2 and Table 3 that DECLS is the best in all the unimodal functions except on Function 4 that is the second best. In multimodal functions, DERLS is the best on Functions 8, 10 and 11. DECLS found the exact optimum all the times in Functions 12 and 13. The basic, DE performed the worst in multimodal functions. According to the above analysis, we can say that DECLS improve a lot the performance of basic DE with random mutation strategy and also we found out that DERLS is really good in multimodal functions particularly on Function 8, which is the most difficult function. Considering all the functions and the average ranking in Table 3, the best algorithm is DECLS and the weakest one is the basic DE.

TABLE II: Average error of the found solutions on the test problems with random mutation strategy

FUNC.	DE	DERLS	DENLS	DECLS
f1	**0,00E+00** (4,56E-14)	**0,00E+00** (6,80E-13)	**0,00E+00** (1,21E-13)	**0,00E+00** (1,33E-14)
f2	1,82E-08 (1,13E-08)	5,30E-08 (2,39E-08)	2,26E-08 (1,32E-08)	**1,42E-08** (1,07E-08)
f3	6,55E+01 (3,92E+01)	8,01E+01 (4,88E+01)	1,11E+00 (1,10E+00)	**6,54E-01** (1,47E+01)
f4	6,22E+00 (5,07E+00)	2,37E+00 (1,87E+00)	1,80E-02 (7,28E-01)	**5,66E-01** (3,68E-01)
f5	2,31E+01 (2,00E+01)	2,27E+01 (1,81E+01)	2,65E+01 (2,41E+01)	**2,03E+01** (2,62E+01)
f6	**0,00E+00** (0,00E+00)	**0,00E+00** (0,00E+00)	**0,00E+00** (0,00E+00)	**0,00E+00** (0,00E+00)
f7	1,20E-01 (3,79E-03)	1,15E-02 (3,16E-03)	1,23E-02 (3,29E-03)	**1,05E-02** (3,61E-03)
f8	2,72E+03 (8,15E+02)	**2,31E+02** (1,50E+02)	1,86E+03 (5,46E+02)	1,58E+03 (5,16E+02)
f9	1,30E+01 (3,70E+00)	1,28E+01 (3,72E+00)	**6,17E+00** (2,06E+00)	7,72E+00 (2,43E+00)
f10	1,88E+01 (4,28E+00)	**1,87E+00** (4,76E+00)	4,94E+00 (8,11E+00)	5,50E+00 (7,53E+00)
f11	**8,22E-04** (2,49E-03)	**8,22E-04** (2,49E-03)	1,49E-02 (2,44E-02)	1,44E-02 (2,70E-02)
f12	3,46E-03 (1,86E-02)	3,46E-03 (1,86E-02)	1,04E-02 (3,11E-02)	**0,00E+00** (8,49E-15)
f13	3,66E-04 (1,97E-03)	**0,00E+00** (2,14E-13)	**0,00E+00** (1,31E-14)	**0,00E+00** (3,37E-15)

TABLE III: Ranking of all DE approaches with random mutation strategy

FUNCTION	DE	DERLS	DENLS	DECLS
f1	**2,5**	**2,5**	**2,5**	**2,5**
f2	2	4	3	**1**
f3	3	4	2	**1**
f4	4	3	**1**	2
f5	3	2	4	**1**
f6	**2,5**	**2,5**	**2,5**	**2,5**
f7	3	2	4	**1**
f8	4	**1**	3	2
f9	4	3	**1**	2
f10	4	**1**	2	3
f11	**1,5**	**1,5**	4	3
f12	2,5	2,5	4	**1**
f13	4	**2**	**2**	**2**
average	3,076923	2,384615	2,692308	**1,846154**

TABLE IV: Average error of the found solutions on the test problems with current to rand mutation strategy

FUNC.	DE	DERLS	DENLS	DECLS
f1	**0,00E+00** (1,20E-16)	**0,00E+00** (5,50E-15)	**0,00E+00** (2,53E-16)	**0,00E+00** (5,23E-17)
f2	**0,00E+00** (6,79E-10)	**0,00E+00** (2,68E-09)	**0,00E+00** (1,65E-09)	**0,00E+00** (8,09E-10)
f3	1,96E+01 (9,93E+00)	1,99E+01 (1,16E+01)	**3,89E-01** (2,94E-01)	4,46E-01 (3,29E-01)
f4	3,30E+00 (2,81E+00)	1,39E+00 (1,66E+00)	6,19E-01 (1,64E+00)	**9,44E-02** (2,14E-01)
f5	1,57E+01 (1,48E+01)	1,91E+01 (1,82E+01)	2,70E+01 (2,70E+01)	**1,49E+01** (1,94E+01)
f6	**0,00E+00** (0,00E+00)	**0,00E+00** (0,00E+00)	**0,00E+00** (0,00E+00)	**0,00E+00** (0,00E+00)
f7	9,64E-03 (9,93E-03)	9,36E-03 (2,63E-03)	9,57E-03 (2,21E-03)	**9,04E-03** (3,22E-03)
f8	6,71E+03 (2,93E+02)	**1,20E+03** (2,78E+02)	5,17E+03 (6,33E+02)	4,02E+03 (6,01E+02)
f9	1,08E+01 (2,39E+00)	1,37E+01 (4,45E+00)	1,04E+01 (3,72E+00)	**1,01E+01** (3,41E+00)
f10	1,93E+01 (3,58E+00)	**4,62E-01** (2,49E+00)	6,92E+00 (9,22E+00)	1,59E+00 (4,86E+00)
f11	**2,47E-04** (1,33E-03)	4,93E-04 (1,84E-03)	9,04E-03 (2,09E-02)	3,77E-03 (7,87E-03)
f12	**0,00E+00** (1,61E-17)	**0,00E+00** (5,02E-17)	3,46E-03 (1,86E-02)	**0,00E+00** (9,99E-18)
f13	**0,00E+00** (1,85E-13)	**0,00E+00** (1,68E-11)	**0,00E+00** (2,48E-12)	**0,00E+00** (6,99E-15)

TABLE V: Ranking of all approaches with current to rand mutation strategy

FUNCTION	DE	DERLS	DENLS	DECLS
f1	**2,5**	**2,5**	**2,5**	**2,5**
f2	**2,5**	**2,5**	**2,5**	**2,5**
f3	3	4	**1**	2
f4	4	3	2	**1**
f5	2	3	4	**1**
f6	3	4	2	**1**
f7	2	4	3	**1**
f8	3,5	**1**	3,5	2
f9	4	3	2	**1**
f10	4	**1**	3	2
f11	**1**	2	4	3
f12	**2**	**2**	4	**2**
f13	**2,5**	**2,5**	**2,5**	**2,5**
average	2,846152	2,461538	2,769231	**1,923077**

C. Performance of the Memetic DE with Current to Rand Mutation Strategy

The next mutation strategy used in our experiments was current to rand mutation strategy (DE/current-to-rand/1) and the results are illustrated in Table 4. The first column of this table shows the functions that we used for testing and the results for every algorithm are given in Columns 2-5.

Table 5 shows the ranking of all the approaches for every test function with current to rand mutation strategy.

We can see in Table 4 and Table 5 that in unimodal functions the best algorithm is DECLS except in Function 3 DENLS is the best. In multimodal functions, basic DE is the worst, because it has the worst results in Functions 8 and 10, two of the most difficult functions and basic DE did not find good result in Function 9. The best algorithms in multimodal functions are DECLS and DERLS. According to this analysis we can say that DECLS is most desirable as it appeared to be competent in all functions, also in the average ranking DECLS gets the best result.

D. Performance of the Memetic DE with Current to Best Mutation Strategy

The last experiments were related with current to best mutation strategy (DE/current-to-best/1). This mutation strategy was used in all DE approaches to study the effect of our proposed ERS strategies in the memetic DE algorithm. The results can be observed in Table 6 and the values in boldface represent the lowest average error found by the approaches.

In Table 7 there is a ranking among all the approaches for every function. The last row represents the average of the rankings.

We can see in Table 6 and Table 7 that DECLS got the best results in most unimodal functions. DERLS is the best on Functions 8 and 10, always finding the true optimum in Function 10. DECLS is the best algorithm in Function 9 and only this algorithm always found the true optimum in Functions 12 and 13. According to the above analysis, we can say that DECLS is the best algorithm, because it is competitive in almost all unimodal and multimodal functions. DECLS also

TABLE VI: Average error of the found solutions on the test problems with current to best mutation strategy

FUNC.	DE	DERLS	DENLS	DECLS
f1	**0,00E+00** (1,81E-34)	**0,00E+00** (8,64E-32)	**0,00E+00** (1,14E-33)	**0,00E+00** (1,04E-33)
f2	**0,00E+00** (9,16E-20)	**0,00E+00** (5,69E-19)	**0,00E+00** (7,19E-19)	**0,00E+00** (3,02E-19)
f3	**2,73E-03** (2,57E-03)	7,27E-03 (8,06E-03)	5,97E-02 (3,21E-01)	5,09E-03 (2,64E-02)
f4	6,42E-04 (5,95E-04)	2,69E-03 (4,72E-03)	2,98E-04 (2,47E-04)	**1,86E-04** (1,93E-04)
f5	4,10E-01 (1,19E+00)	4,34E-01 (1,23E+00)	1,97E+00 (3,64E+00)	**1,07E+00** (1,75E+00)
f6	2,33E-01 (4,23E-01)	2,67E-01 (5,12E-01)	6,67E-02 (2,49E-01)	**0,00E+00** (0,00E+00)
f7	7,94E-03 (2,45E-03)	8,54E-03 (2,21E-03)	8,33E-03 (3,40E-03)	**7,77E-03** (2,40E-03)
f8	2,35E+03 (8,66E+02)	**3,10E+02** (1,86E+02)	2,35E+03 (5,85E+02)	2,10E+03 (5,75E+02)
f9	2,18E+01 (4,47E+00)	2,02E+01 (5,13E+00)	1,23E+01 (6,08E+00)	**1,08E+01** (3,72E+00)
f10	1,06E+01 (9,89E+00)	**0,00E+00** (1,28E-15)	2,78E+00 (6,44E+00)	1,99E+00 (5,87E+00)
f11	**4,76E-03** (5,28E-03)	9,52E-03 (8,59E-03)	1,16E-01 (8,04E-02)	1,01E-01 (6,79E-02)
f12	2,76E-02 (5,31E-02)	1,04E-02 (3,11E-02)	1,42E-01 (3,21E-01)	**0,00E+00** (8,22E-33)
f13	1,83E-03 (4,09E-03)	3,66E-04 (1,97E-03)	4,36E-04 (1,64E-03)	**0,00E+00** (2,57E-09)

TABLE VII: Ranking of all DE approaches with random mutation strategy

FUNCTION	DE	DERLS	DENLS	DECLS
f1	**2,5**	**2,5**	**2,5**	**2,5**
f2	**2,5**	**2,5**	**2,5**	**2,5**
f3	**1**	3	4	2
f4	3	4	2	**1**
f5	**1**	2	4	3
f6	3	4	2	**1**
f7	2	4	3	**1**
f8	3,5	**1**	3,5	2
f9	4	3	2	**1**
f10	4	**1**	3	2
f11	**1**	2	4	3
f12	3	2	4	**1**
f13	4	3	3	**1**
average	2,653846	2,538462	3,038462	**1,769231**

gets the best ranking among others. Besides, DERLS is shown to be competitive in multimodal functions.

VI. CONCLUSIONS

In this paper we propose a memetic DE algorithm by incorporating Eager Random Search (ERS) as a local search method to enhance the search ability of a pure DE algorithm. Three concrete local search strategies (RLS, NLS, and CLS) are introduced and explained as instances of the general ERS method. The use of different local search strategies from the ERS family leads to variants of the proposed memetic DE algorithm, which are abbreviated as DERLS, DENLS and DECLS respectively. The results of the experiments have demonstrated that the overall ranking of DECLS is superior to the ranking of basic DE and other memetic DE variants considering all the test functions and various mutation strategies used. In addition, we found out that DERLS is much better than the other counterparts in very difficult multimodal functions.

In future work, we intend to improve our proposed algorithms with adaptive parameters in mutation, crossover and local search and attempting to hybridize both alternatives to take advantage of the best features from each of them. Moreover, we will also apply and test our new computing algorithms in real industrial scenarios.

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