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Garbage Bin Monitoring System Based on the Internet of Things at University Dirgantara Marsekal Suryadarma

Nurwijayanti. KN
Electrical Engineering, Faculty of Industrial Technology, Universitas Marsekal Dirgantara Suryadarma
Jl. Protokol Halim Perdanakusuma Jakarta Timur 13610 – Indonesia
E-mail: nurwijayanti_kn@yahoo.com

Rhekaz Eka Adhytyas
Electrical Engineering, Faculty of Industrial Technology, Universitas Marsekal Dirgantara Suryadarma
Jl. Protokol Halim Perdanakusuma Jakarta Timur 13610 – Indonesia
E-mail: rhekaz.eka@gmail.com

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Abstract: Garbage is a major problem, because it can harm human health, cause bad odors, and air pollution. With the existence of trash bins, it seems that it doesn't matter because most people prefer to litter, as well as cleaning workers to check the capacity of the trash can who often forget to cause garbage to accumulate so that it can pollute the environment.

To solve the waste problem, especially at universities, a smart campus concept was created to solve the problem of waste management. By utilizing GPS technology, Internet of Things, Wi-fi technology that is already available, and other hardware devices such as Arduino microcontrollers, ultrasonic sensors, and others.

With this concept, it is hoped that the cleaning staff will arrive on time to transport the garbage according to the information from the existing application, where the information has shown the coordinates of the full trash can so that cleanliness and comfort are maintained.

Index Terms: IoT, Smart Trash Box, Location, Smart Campus, Information Systems, GPS

1. Introduction

Garbage is a major problem that is often faced by the people of Indonesia, especially household waste, especially in the process of disposal, management and transportation of waste which is often late, causing an unpleasant odor. The research objective is to create a smart campus concept by utilizing IoT (Internet of Things) technology which is connected to a trash can using android media and a microcontroller as a connecting medium, as a solution to the problem of garbage accumulation [1,2,3,4].

IoT technology is a concept that uses the internet as the main infrastructure network that connects Certain objects and applications of IoT can be clarified into various uses, such as smart home, smart campus and others [5,6].

The limitation in this research is applying IoT technology at the University of Dirgantara Marshal Suryadarma which can contribute to the cleaning staff, because so far there has been no information when the trash can is full. This technology is linked to a GPS location so that cleaners can easily find their location quickly.

It is hoped that by implementing an IoT-based smart campus, the waste problem can be overcome, the campus environment is kept clean and this technology can make human work easier.

A. Smart City / Smart Campus

Smart city / smart campus is city / place by applying the smart city/place concept, [7] to facilitate the people in that place get/ send information quickly and accurately and can share integration direct information with the community other people outside the region.[8, 9]

The campus is a place to gain knowledge, so it requires a clean and comfortable environment from all pollution.

Pollution that often occurs in the campus environment is garbage that is scattered or trash cans that are full but have not been transported by cleaners. This is due to a lack of information for the cleaning staff.

So a smart campus concept was designed with the support of an adequate wi-fi network and internet, [10-14] the combined technology is IoT technology and computer technology that are integrated [15], with the addition of Arduino

devices, GPS and sensors, sensors installed in each trash can around the campus which functions as an indicator of the trash can, the indicator is empty, half full and full.

This concept is used so that when the trash can is full it will send the coordinate points of the trash, to make it easier for cleaning officers to pick up trash so that the cleanliness and beauty of the campus are maintained.

B. Internet of Things (IoT)

Internet of Things is a concept in which certain objects can transfer data over a network without requiring human-to-human or human-to-computer interaction.[16,17]

The Internet of Things is often referred to by its abbreviation, IoT, which has grown rapidly from the convergence of wireless technology, micro-electromechanical systems (MEMS), and also the Internet. [18]

IoT works by utilizing a programming argument, where each of these argument commands can produce an interaction between machines that have been connected automatically without human intervention and without being limited to any distance.[19]

The application of IoT in various fields, especially the environment, to keep the environment clean on campus a concept is made to keep the environment clean by applying IoT.

C. Global Positioning System (GPS)

This signal is received by the receiver on the surface and is used to determine the location, speed, direction, and time. Systems that are similar to GPS include Russian GLONASS, European Union Galileo, India's IRNSS GPS, whose real name is NAVSTAR GPS (Navigation Satellite Timing and Ranging Global Positioning System), which has three segments, namely: satellite, controller, and receiver/user [20]. GPS satellites orbiting the earth, with fixed orbits and positions (exact coordinates), [21] a total of 24 of which 21 are active and the remaining 3 are reserves. To be able to find out a person's position, a device called a GPS receiver is needed which functions to receive signals sent from GPS satellites.

The way these GPS works is that the most important part of the GPS navigation system is that several satellites are in earth orbit or what we often call in space. There are currently 24 GPS satellites, all of which can transmit signals to earth which can then be captured by the signal receiver or GPS Tracker.

D. Method

This research combines 3 technology concepts, namely the Internet of thinks, GPS, and Smart campus, supported by other components such as sensors, microcontrollers, computers, and other hardware.

The uniqueness of this research is to make Marsekal Suryadarma University Aerospace a unique campus, namely a smart campus, the Marsekal Suryadarma Aerospace University already has good Wi-Fi facilities and its coverage is quite wide, so GPS and IoT technology is combined into a facility to keep the environment clean and beautiful. campus, which is a smart trash can.

This trash can provide height information from the trash that is in it by activating the indicator, empty, half, and full. If the trash can is full, it will send the location of the coordinate point of the full trash can into an application, then the sensor in each trash can gives a signal to the cleaning officer via a message sent to an application, it is hoped that the cleaning officer will immediately transport it. the garbage. and cleaners do not need to find which trash can be taken but have gone straight to the target according to the coordinate position.

2. Research Methods

In conducting this research, there are several stages to complete this research as shown in Fig.1.

The research was conducted at one location using 3 bins, namely empty, half, and full conditions. Each trash can has a sensor installed to provide an indicator of the condition of the trash.

Then design a system that is connected to a GPS so that it can provide the coordinates of the full trash can to cleaners using the (Internet of things) IoT technology [13].

Followed by system testing so that it can be seen how long it takes to send information from a full trash can to the cleaning officer.

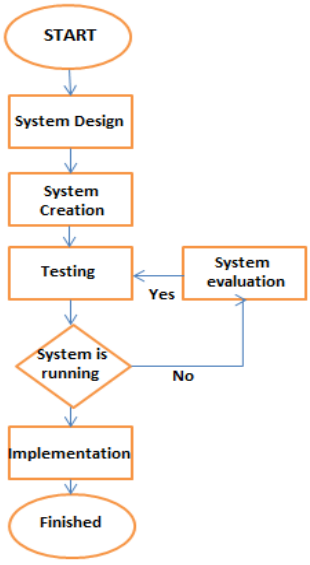

Fig. 1. Flowchart

3. Results and Discussion

A. Current System Analysis

This smart trash box system has 2 functions, namely. The first function is to monitor the condition of the trash, including the height of the trash using an ultrasonic sensor [8]. And the second function is to monitor the location of the trash can be placed using GPS, Monitoring data will be displayed on the application on a PC or Laptop [12].

B. Needs Analysis

At this point, it focuses on functional requirements, non-functional requirements, hardware requirements, software requirements of the systems or tools that have been created.

- Functional Requirements Analysis

The functional requirements of this system or tool include:

1. This tool can be used as a monitoring of the height of the waste.
2. Monitor the location of the trash.

- Analysis of Non-Functional Requirements

The non-functional requirements of this system or tool include:

1. The monitoring and control process of this system is quite easy because it can be controlled from anywhere and anytime. It is enough to connect the device to a wifi network so that it is connected to the internet [22].
2. Improve the impression that the trash can is attractive, easy, and hygienic because no trash comes out through the trash.

- Hardware Requirements Analysis (Hardware)

Hardware requirements (hardware) is an analysis of system requirements that are used to determine the devices needed to support the development process and use of the system to be made. The hardware required is as follows:

1. ESP8266 NodeMCU Module
2. Ultrasonic Sensor (HC-SR04)
3. Shield NodeMCU ESP8266
4. 5V power supply
5. GPS uBlox GY-NEO6MV2

- Software Requirements Analysis (Software)

Software requirements (software), namely the programs needed to perform the instruction process run hardware. So that a system or tool can be created and implemented according to the design, the software is needed. The software specifications required by the system are:

1. The Arduino IDE is used to program the Arduino wifi shield according to the design that has been made [23].
2. Borland Delphi was used to create monitoring applications for research projects [24,25].

C. System Planning

System design is an advanced stage of analysis and evaluation of an ongoing system, in which this section will describe the system design that will be built before programming into a programming language [24]. In designing a system it cannot be separated from the results of the analysis, because from the results of the analysis a new system can be made to produce a system design.

- System Design Objectives

The purpose of system design, in general, is to provide a general overview to the user about the new system. System design in general is a preparation of the detailed design. In this study, the system design aims to describe in general the design of the smart trash box prototype to the user about the system to be built and identify the components of the information system to be designed in detail.

- Data Flow Chart

The data flow diagram in this study describes how the process of sending data obtained from sensors installed in the trash box to the Borland Delphi application server, then from the server will be displayed on applications that have been installed on a PC or laptop. Fig. 2 shows the data flow diagram.

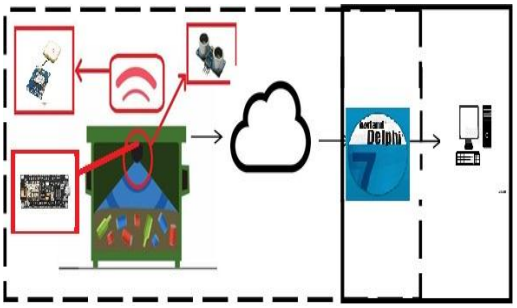

Fig 2. Smart Garbage System Block Diagram

D. Testing

Fig.3 shows the smart garbage application which has 3 main commands namely open the map, update the time limit, and monitor the trash data on the main page.

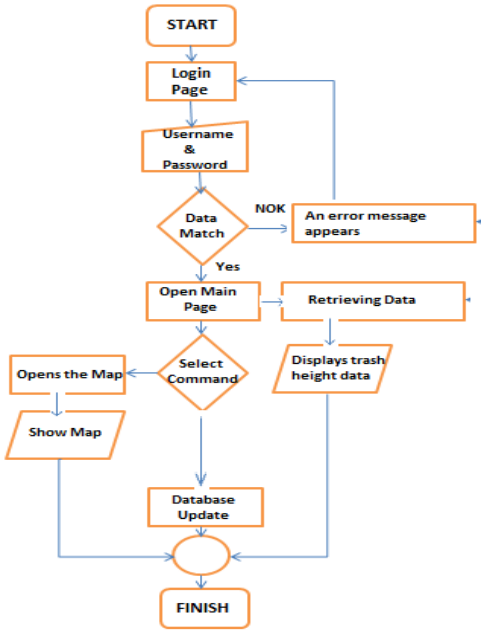

Fig 3. Smart garbage application design

The application will open the login page for the first time it is opened. If the user already has an account, they can log in. After logging in, the user will be taken to the main page.

- Data Flow Diagram

The data that is streamed in the smart garbage application can be seen in the Data Flow Diagram in Fig. 4

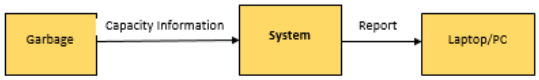

Fig.4. Data Flow Diagram

- Interface Design

To build a "Smart Garbage Monitoring System" it is necessary to design an interface as an illustration of the application to be made, which is as follows:

1. Interface Design Login Page

The login page consists of a username, password to enter the main page. As in Fig. 5, below

Fig 5. Login activity diagram

Fig. 6 shows the login activity diagram for the Delphi program.

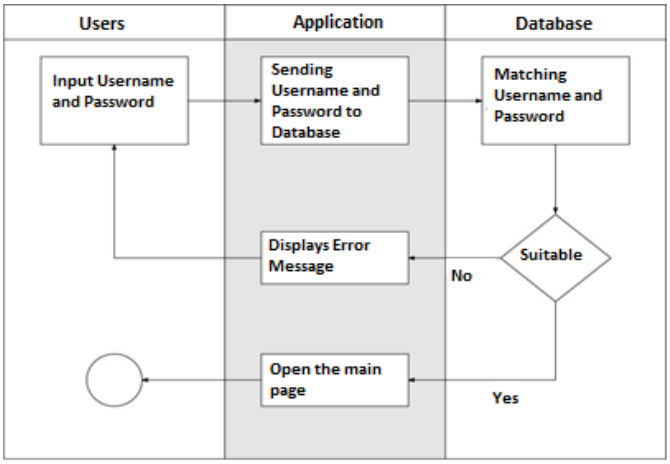

Fig 6. Login activity diagram

The sign-in process takes advantage of the authentication features Delphi provides. The user enters the username and password in the application and is authenticated by Delphi. [25] If the username and password do not match the data registered in Delphi then the application will provide an error message, and if it matches the registered data the application will proceed to the main page. Fig. 7 shows the wrong username and password page contains only a description to try again.

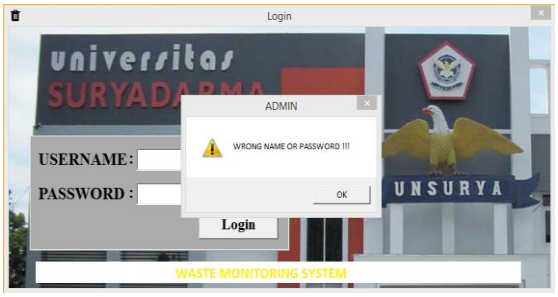

Fig 7. Incorrect Username Password page

2. Main page design

Fig. 8 shows the existing waste status display menu, of the existing trash in the form of the height level of the trash and the time limit for transporting the trash.

Fig 8. Main page view

3. Design map view

Fig 9. shows the map will display a "red arrow" indicating the location of the trash based on the latitude and longitude in the database.

Fig 9. Map view

Fig. 10 shows the map activity diagram for the Delphi application.

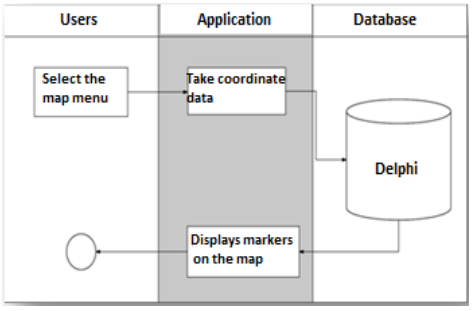

Fig 10. Map page activity diagram

- Testing the login form

Table 1 shows that the test was carried out using the username and password specified by the admin.

Table 1. Testing the login form

No	Testing Components	Expected results	Test image	Status
1	Username and Password not registered	An input error message appears		suitable
2	Registered username and unregistered Password	An input error message appears		suitable
3	Username is not registered and Password is registered	An input error message appears		suitable
4	Registered username and password	Enter the main page		suitable

- Testing the data reading level of the height of the trash

Table 2 shows the Test was carried out to determine the reading of the height of the trash in the application according to the data in the database. Tests are carried out by equating the data on the height of the trash that enters the database with the data displayed in the application.

Table 2. Testing the data reading level of the height of the trash

Testing to-	Result			Status
	Height 0 cm - 4 cm	Height 5 cm - 15 cm	Height16 cm - 30 cm	
1	A notification appears Empty trash can	A trash can notification appears half full	A notification appears Trash can full	suitable
2	A notification appears Empty trash can	A trash can notification appears half full	A notification appears Trash can full	suitable
3	A notification appears Empty trash can	A trash can notification appears half full	A notification appears Trash can full	suitable
4	A notification appears Empty trash can	A trash can notification appears half full	A notification appears Trash can full	suitable
5	A notification appears	A trash can notification appears half full	A notification appears Trash can full	suitable
6	A notification appears Empty trash can	A trash can notification appears half full	A notification appears Trash can full	suitable

7	A notification appears	A trash can notification appears half full	A notification appears Trash can full	suitable
8	A notification appears Empty trash can	A trash can notification appears	A notification appears Trash can full	suitable
9	A notification appears Empty trash can	A trash can notification appears half full	A notification appears Trash can full	suitable
10	A notification appears Empty trash can	A trash can notification appears half full	A notification appears Trash can full	suitable

- Testing the notification level of the trash can level

Table 3 shows that the test was carried out to determine the height level notification features that have been made in the application as expected. The test is carried out in two different conditions, namely when the application is opened and when the application is running in the background with an initial value of 16-30 cm. a notification will appear when the altitude data has passed 6 - 15 cm or 0 - 5 cm from the height of the trash.

Table 3. Waste level notification test

Testing to-	Result			Status
	Height 0 cm - 14 cm	Height15 cm - 24 cm	Height 25 cm - 30 cm	
1	Indicator light up white	Indicator light up yellow	Indicator light up red	suitable
2	Indicator light up white	Indicator light up yellow	Indicator light up red	suitable
3	Indicator light up white	Indicator light up yellow	Indicator light up red	suitable
4	Indicator light up white	Indicator light up yellow	Indicator light up red	suitable
5	Indicator light up white	Indicator light up yellow	Indicator light up red	suitable
6	Indicator light up white	Indicator light up yellow	Indicator light up red	suitable
7	Indicator light up white	Indicator light up yellow	Indicator light up red	suitable
8	Indicator light up white	Indicator light up yellow	Indicator light up red	suitable
9	Indicator light up white	Indicator light up yellow	Indicator light up red	suitable
10	Indicator light up white	Indicator light up yellow	Indicator light up red	suitable

Fig, 11, fig. 12, and fig. 13 show the condition of the until the place is empty, half, and full.

Fig. 11. The trash can indicator is white and an Empty notification appears

Fig. 12. The trash indicator is white and a notification is half full

Fig 13. The trash indicator is white and a full notification appears

- Testing the suitability of the trash bin location

Table 4 shows that the test is done by retrieving location data from the delivery of trash bins in the database. The location data used in the test amounted to five different trash can locations, then see the suitability of the locations on the map that was created in the application and compare them with the coordinates on the google map.

Table 4. Location reading test

Location name	Coordinate	Data from the application	Google map (WEB)	Status
User	"-6.137.683, 106.69291 0"	Latitude : -6.137683 Longitude : 106.692910 Altitude : 29.40 Date : 12/24/2019 Time : 04:00:33.00		suitable
Radit Cell	"-6.137495,106.69 2819 "	Latitude : -6.137495 Longitude : 106.692819 Altitude : 15.10 Date : 12/24/2019 Time : 08:21:29.00		suitable
Chairman House	"-6.137936,106.69 3590 "	Latitude : -6.137936 Longitude : 106.693590 Altitude : 32.60 Date : 12/24/2019 Time : 07:35:05.00		suitable
ZaFakids Fashion Store	"-6.137572,106.69321 6"	Latitude : -6.137572 Longitude : 106.693216 Altitude : 6.20 Date : 12/24/2019 Time : 08:12:46.00		suitable
Ayam Bakar Kreweng	"-6.137307,106.69260 8"	Latitude : -6.137307 Longitude : 106.692608 Altitude : 32.80 Date : 12/24/2019 Time : 07:30:38.00		suitable

4. Conclusion

The test results show that the application features that have been made can run according to their function, from the test results that at the height of the trash can 16 cm - 30 cm the application will display a red indicator with a complete trash can description. and the layout of the trash, if the height of the trash is 5 cm - 15 cm the application will display an orange indicator with a half-full description, the trash height is 0 cm - 4 cm. The app will display a white indicator with an empty trash can.

When the trash bin indicator is full, it only takes 10 minutes for the information to reach the cleaning officer. This IoT technology will continue to monitor the height of each trash can in the environment of Marsekal Suryadarma University Dirgantara, it is hoped that this smart campus concept will take advantage of technological developments, increasingly expanding in residential locations, offices, restaurants. and others, all of which are connected to the sanitation department so that environmental cleanliness stays awake from scattered trash.

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We are grateful to Mrs. Bekti Yulianti as the head of the Electrical Engineering Study Program and Mr. Yohannes Dewanto as the head of the electrical engineering laboratory who has provided many valuable suggestions, as well as moral support and encouragement in progress this project succeeded in making the campus smart. Hopefully, this project will be sustainable and beneficial for the campus environment in keeping the environment clean.

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Authors' Profiles

Nurwijayanti KN, born in Jakarta. January 19, 1976. Last education was a master's in Electrical Engineering, majoring in Telecommunications University of Indonesia, Depok, Indonesia, Graduated in February 2003.

Began working as a lecturer in the electrical engineering study program Universitas Dirgantara Marsekal Suryadarma in 2001 and Tarumanegara University in 2006.

Competent research fields are telecommunication, network, and computers, there are 12 published articles, published in national journals and several international proceedings.

Rhekaz Eka Adhytyas, Born in Jakarta, Last education was the electrical engineering specialization in Telecommunications, Universitas Dirgantara Marsekal Suryadarma.
Currenty working at PT. ZTE Indonesia, MNC Park Tower Building Kebon Sirih, West Jakarta

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The Cell Cycle Model: A Comprehensive Review and Extension Based on Machine Learning

Mustafa Kamal Pasha[a], Khurram Munawar[a], Asma Talib Qureshi[b]
[a]Department of Environment, Society and Design, Lincoln University - New Zealand
[b]Department of Healthcare Biotechnology, National University of Sciences and Technology – Pakistan
E-mail: kpasha2003@gmail.com

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Abstract: The cell cycle is a conserved process comprising of an organized series of interdependent and cross regulatory events that lead to controlled cell growth and proliferation. Genomic and volume regulatory processes are of special interest as they decide the fate of cell cycle. Signaling cascades including MAPK, PI3K, Sonic Hedgehog, Wnt and NOTCH signaling pathways are few well known conventional players contributing in controlling the cell cycle progression through different phases by expressing certain proteins. Moreover, the unconventional volume regulatory players exert influence by regulating membrane potential that is determined by ions influx or efflux across the plasma membrane via ion channels, controlling water movement and ultimately contributing to volume increase in growth phases of the cell cycle. Both of these players are interlinked, therefore, in order to establish a better understanding of the interdependence of these players, principles of machine learning were applied on data obtained on cell cycle. The data was processed by using neural networks and it shows that a significant understanding of conventional regulators is available in the literature and it has been under the limelight as well. However, when it comes to unconventional volume regulatory players, a limited understanding is available. Moreover, the precise role of each component and its interdependence with other is not yet fully understood. Due to which, they are not clearly evaluated for their potential role as cell cycle control elements for therapeutic purposes. Therefore, this study aims to summarize the data on cell cycle that is obtained through machine learning and to discuss the advances in cell cycle modelling mechanisms and designs that are based on different mathematical algorithms. Thus, this review will provide a basis to clearly understand and interlink the discoveries on cell cycle so that a comprehensive cell cycle model could be built which, if manipulated can be used for therapeutic purposes by identifying the least explored regulatory control elements.

Index Terms: Cell cycle, Intelligent modelling, computational modelling, and role of Ca^{2+} signaling, Artificial Neural Network, machine learning

1. Introduction

The cell is a fundamental unit of life and plays a crucial role in organ and system development, transportation and storage of biomolecules, gene expression, signal transduction, and empowerment of molecular machineries [1]. The process of a cell dividing into two daughter cells is known as the cell cycle, which is a universal and complex process and is tightly regulated by different regulatory proteins that either allow or limit its progression [2]. A cell progresses to cell division by receiving growth and proliferative signals from the extracellular environment. In response to these cues, a cell quits G0 phase and enters into the G1 phase of the cell cycle. The G1 is one of the two growth phases in the cell cycle where cell increases in size and accumulates within itself sufficient nutrients to provide energy during a cell cycle. This volume growth is an important regulatory step as it decides the progression of cell into subsequent phase. When all the required conditions are met, a cell progresses to S phase that is the synthesis phase of DNA. Following the S phase is the second growth phase called G2 phase where cell replenishes its energy reserves and grows in size so that it could enter into the mitotic phase, which terminates this cycle at cell division by passing through four substages, starting from prophase and ending at telophase [3]. The first 3 phases G1, S and G2 comprise the longest period in cell cycle known as interphase [4]. There are few mammalian cells, for instance epithelial cells, which continually grow and divide while other cells stay in quiescent phase and perform normal metabolic functions like muscle cells or neurons. Investigators have postulated and later proved that these cells stay longer in G0 phase and upon receiving stimulus they continue proliferation or differentiation. This longer stay in the quiescent phase has been distinguished as G0 phase distinct from G1 phase [5].

Upon receiving mitogenic signals, changes in cellular dynamics are observed due to activation of certain signalling pathways which ultimately cause transcription of proliferative genes by expressing transcription factors like FOS, JUN,

cMYC etc. Some of these signalling cascades are MAPK pathway, PI3K/Akt/mTOR pathway, NOTCH pathway, SHH and Wnt signalling pathway. All of these pathways play a significant role in cell cycle progression by directly influencing the genetic machinery and transcribing the genes and expressing proteins essential for cell progression through different cell cycle phases. The most crucial regulatory proteins responsible for transition and transversion of cell cycle checkpoints are Cyclins and Cyclin Dependent Kinases (CDKs) along with their inhibitors, and tumor suppressor genes p53 and pRb and associated regulators [2]. These regulatory signalling molecules are considered to be the conventional drivers in cell cycle control throughout its four basic stages to complete the cycle of division, namely: G1, S, G2 and M phase [6].

As research on the cell cycle progressed over years, new regulatory control elements were identified. Initially, the cell cycle was understood to be dependent on a number of different phases that a cell goes through during cell division; however, later, other vital aspects were found. One of these was the role of bioelectricity in driving the process of cell division. This bioelectricity was observed due to influx and efflux of different ions through ion channels that are present on the cell membrane as well as on the nuclear membrane [7]. This flow of ions across the plasma membrane establishes a membrane potential which has been linked with the regulation of the cell cycle since long and are also involved in cancer development and progression. However, how they control cell cycle has not yet been fully elucidated [7].

All these pathways and regulatory elements are intricately interlinked as they all are performing the same function i.e. driving the cell to division. But no study has been conducted till date that would have incorporated these details in a single model to provide a better understanding of the cell cycle. Therefore, in order to get a bigger picture, Artificial Intelligence should be introduced in the domain of biological sciences. Hence, this study aims to evaluate the modelling of the cell cycle of a living organism through machine learning. Previously, the new technologies were only used in the areas of industry and education. But the recent years have seen an increase in the need of integrating the modern age equipment in the field of health and biological sciences [8]. Owing to the increased use of computers and internet sources, machine learning is the idea of vast volumes of data being produced every day in various fields [9,10]. Therefore, approach of machine learning is utilized in this study to evaluate and model the cell cycle. Other than computer, the devices like antennas and wireless devices can also be used for the collection of data. As the data collected through these devices would have large benefits, including the domains of personal wellbeing, and biological sciences [11-16]. Therefore, this study utilizes the effectiveness of Neural Networks in order to better understand this whole process of cell division. These Neural Networks work on the similar principle as that of human brain by processing the information in different layers. These layers are input layer, hidden layer and output layer. Number of layers in hidden layer can be increased depending on availability and complexity of the data. As this study evaluates a huge data set on cell cycle and its regulatory control elements, therefore, we have utilized the effectivity of machine learning and artificial intelligence so that all the data could be processed in the best possible manner through neural networks. The findings of this study would enable researchers to critically evaluate the influence of their research outcomes by incorporating them in a comprehensive cell cycle model. This would on one hand help them in validating their current findings and on the other hand will help in identifying new cellular targets.

2. Methodology

The methodology adopted for this research is shown in Fig. 1.

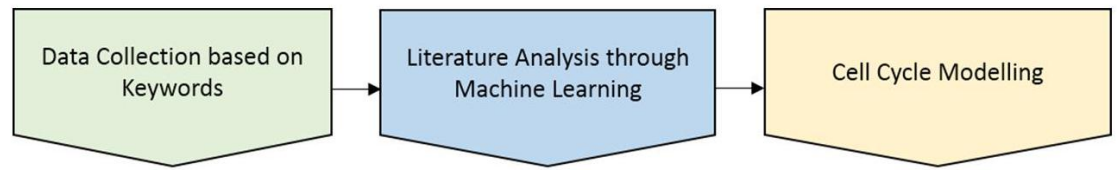

Fig. 1 Methodology based on Machine learning adopted for cell cycle review and modelling

2. 1 Data Retrieval Through Machine Learning

Data required for conducting this research was collected through an extensive literature retrieval from different search engines including Web of science, ScienceDirect, and Scopus, etc., through a combination of index terms. Research from high index papers published in top-tier journals was selected and was further processed by using machine learning and artificial intelligence. A number of keywords were used to obtain relevant literature on cell cycle. The keywords used for this research includes "Cell cycle, Intelligent modelling, computational modelling, role of Ca^{+2} signalling, Artificial Neural Network, cyclin and cyclin dependent kinases, cell cycle machine learning".

2. 2 Modelling and Analysis via Neural Networks

For the collection and review of the complex data on cell cycle, Multilayer Artificial Neural Networks were used in four phases. These layers, as shown in Fig. 2, include, Data Extraction, Pre-processing and preparation, Modelling and Evaluation. The neurons links were made in between these phases. The aim of these complex networks is to find the weight of the data on research domains from cell cycle. Using this ANN model all the data is collected and evaluated in this research.

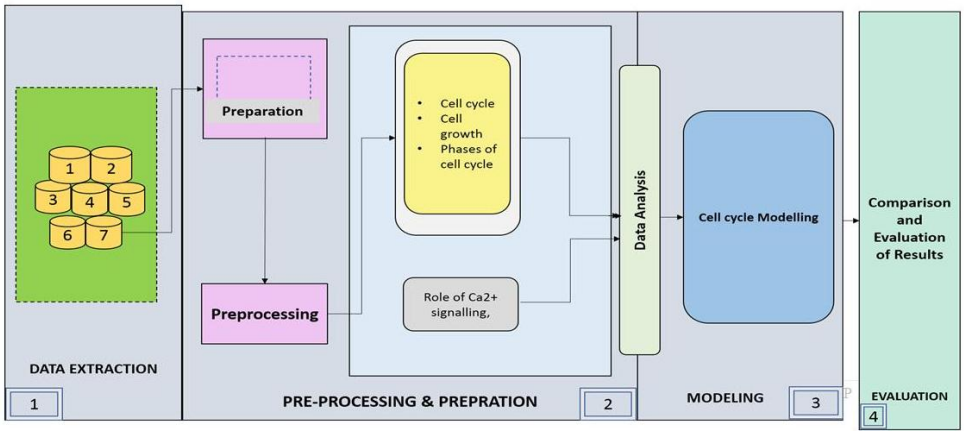

Fig. 2 ANN Model for the data collection

AI based layers are also used for the data classification and evaluation. The layers, as shown in Fig. 3, includes, convolution, pooling, and classifier. The aim of these complex networks is to find the weight of the data. This model helps to collect detailed data on the cell cycle.

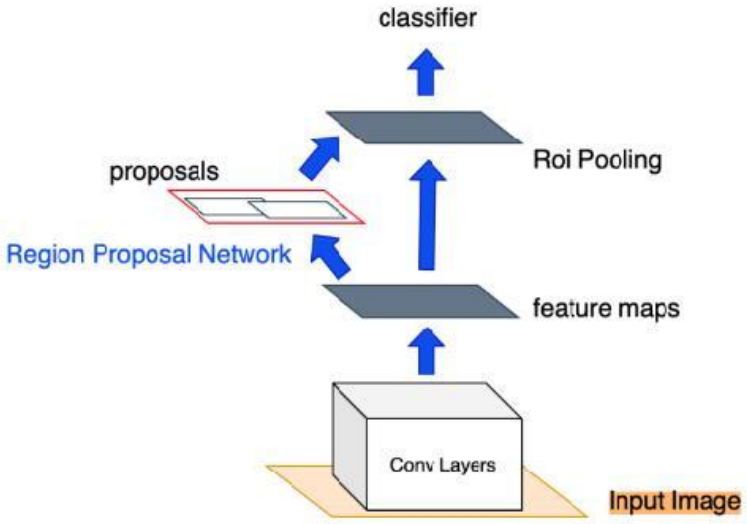

Fig. 3 AI based Model for the data Evaluation

After the data pooling through AI, the data was classified in different cell cycle layers based on ANN. These layers define each stages of cell cycle separately. The framework is shown Fig. 4. Layers adopted in this framework includes input, convolution, activation and full connection with the output layers,

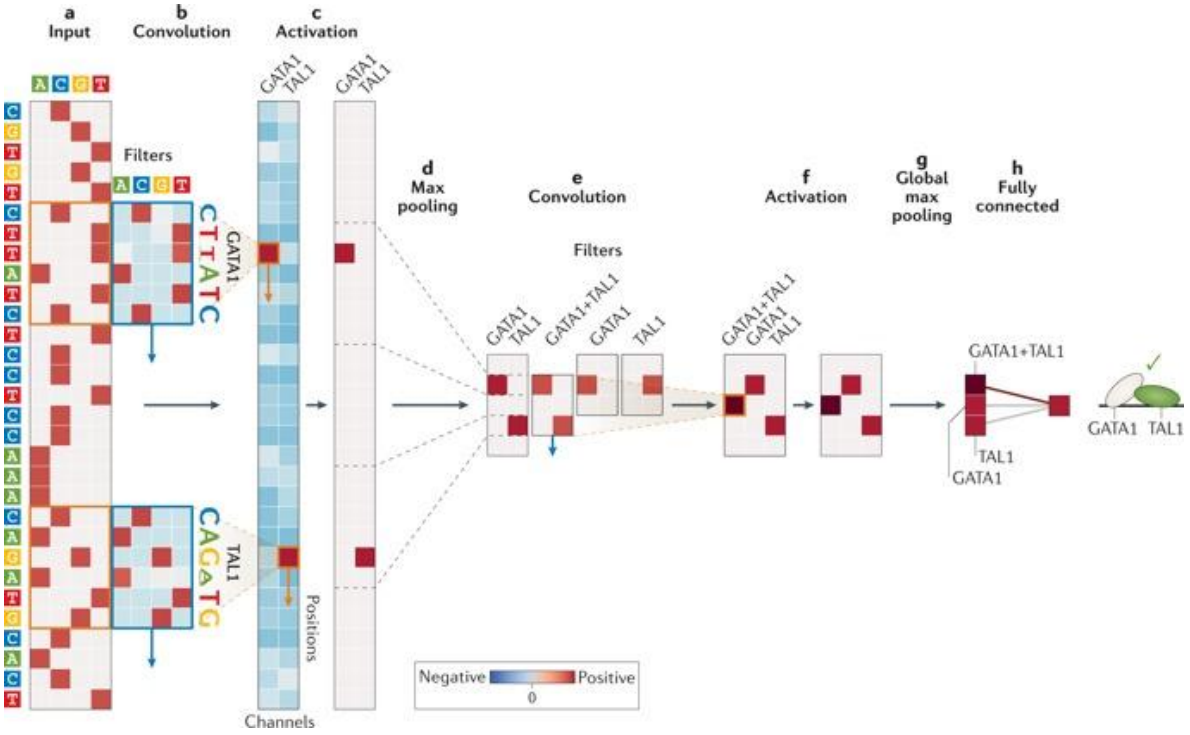

Fig. 4 Data classification based on ANN

3. Results

3.1 Neural Networks

VOSviewer software generated a network from output data of ANN Model based on "Visualization of Similarity" as given in Fig. 5. The nodes of this network represent the domains explored for cell cycle while their size represents the weight of the data, or in other words the amount of work done under these domains. The interconnectedness of these research areas is represented by lines between the nodes. The most repetitive keywords found in the articles include cancer, ca2 signaling, inhibitor, differentiation, cell cycle, apoptosis, kinase, neuron, etc. This clearly shows that research on cell cycle is mostly related to genomic machinery and it lacks the concept of comprehensiveness and inclusion of volume regulatory control elements. Therefore, this study presents a review on the available literature on unconventional elements of cell cycle control by focusing on volume regulatory components which is the main exploratory domain of this research.

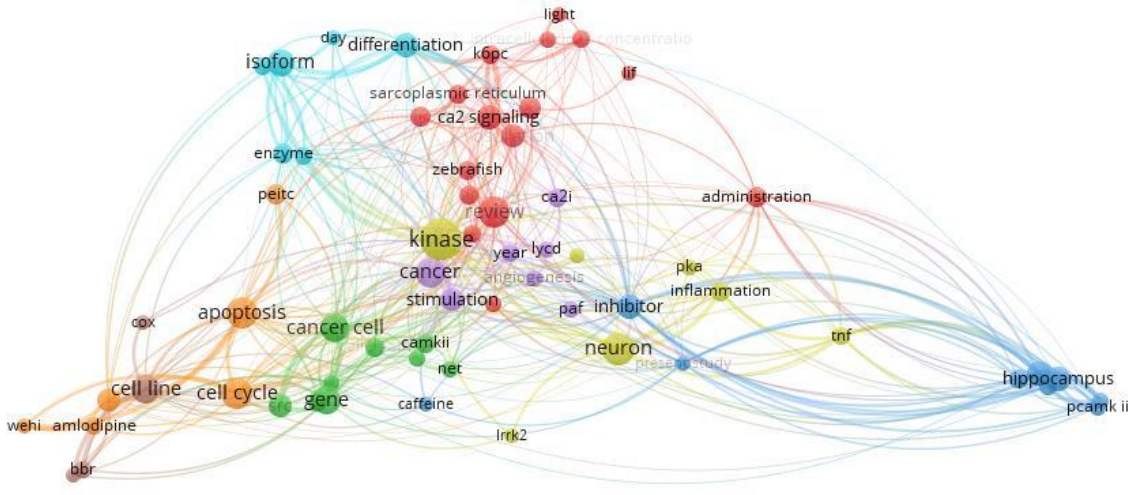

Fig. 5 Most repetitive keywords used in research articles related to cell cycle

3.2 Data Derived through Machine Learning On cell cycle

Based on the results of ANN Model, data on cell cycle was retrieved through machine learning from online sources and is discussed below

3.2.1 G1/S phase transition

According to data pool [9, 17, 18] collected through machine learning, cells stay in G_0 phase and perform several metabolic functions unless they receive a signal from extracellular matrix for progression. This overall progress from G_0 to G1 is tightly controlled by a series of growth factors, including Platelets-Derived Growth Factors (PDGF), Fibroblast Growth Factors (FGF), Insulin like Growth Factors (IGF) and insulin which determine the regulation of the cell cycle phases from one to another. The data also revealed that if the cell does not encounter these growth factors, it then remains in quiescent state [9]. Upon receiving growth factor signals, the cell enters G1 phase and performs a number of distinct activities. It activates pathways which establish Ca^{+2} signalling in waves that plays a role in controlling the cell cycle machinery, increment in cell volume to hold DNA and other copied cellular components, and the synthesis of proteins required for entry into S phase as shown in Fig. 6. According to Pledger, this transitional state occurs late in G1 after satisfying the requirements of the volume control checkpoint and the absence halts the transition into S phase or its deregulation can lead to abnormal cellular transformations and cancer conditions [17]. Moreover, p53 is found responsible in the database for controlling this transition in the case of DNA damage [18] as the controller of cell cycle arrest and DNA repair.

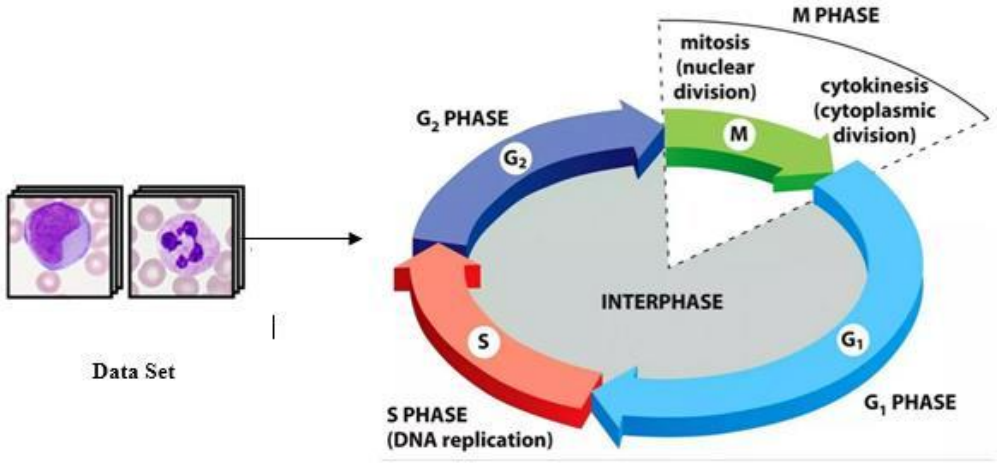

Fig. 6 Phases of Cell Cycle (Interphase and Mitotic phase) (Ravindra B. , 2006)

3.2.2 Establishment of Ca2+ signaling

Ca2+ is found as a ubiquitous molecule in the data pool. According to Rossow, 1979, it controls cell volume, bioelectricity and cytoskeleton and servring in the process of coordinated cell growth in G1 and G2. It was found in literature that the Ca2+ establishment is achieved through initial cell shrinkage and its influx relies on activation of various tyrosine kinase receptors. ANN also revealed that receptor-ligand binding activates the PI3K and the extracellular signal-regulated kinase1/2 (ERK ½), which in turn activates the potassium channels that have kept the membrane potential in a depolarized state to eventually change it to a hyperpolarised state through the activation of calcium channels in mid G1 and towards the transition of G1/S phase [19]. The study of Bartek 2001, states that during mid G1, Phospholipase C is activated, which mediates the release of Ca2+ from the endoplasmic reticulum into the cytoplasm that maintains and regulates the activity of the Ca2+ mediated K+ channels leading to cell volume shrinkage. The hyperpolarized state is thus maintained, mediated by further entry of Ca2+ into the cytoplasm leading to the activation of the transcription factors such as JUN, FOS and c-MYC, which transcribe CDKs and cyclins, such as the p15, p16, p17, p18 and p19 thus inhibiting the activity of the CDK inhibitors (p21 and p27) [20]. Bartek 2001, also states that once the Ca^{+2} is established, volume increase along with early immediate gene expression takes place.

3.2.3 Increment in Cell Volume and Its Control

The phenomenon of volume control has been speculated in the data sets of CNN, to be an important part of the cell cycle. According to Massagué, 2004, nucleus to cytoplasm ratio is found as an important measure in monitoring the increase in cell volume. A continuous increase is evident in the cell volume starting from the G1 phase all the way to the M phase. According to collected data, the role of the cytoskeleton in the regulation of the cell cycle has not been proven yet and there is a perplexed opinion regarding the regulatory mechanisms since the inhibition of the cytoskeleton

through drugs has shown no effect on the cell volume changes. The size of the nucleus has been said to be directly regulated by the nuclear membrane in the data sets. The important catch data provided is that once the cell actively begins the transcription phase, there is a need to control the volume of the cell and its components. According to Massagué, 2004, this is achieved by the involvement of the chloride ions which actively regulate the cell volume. The expression of the EAG2 (K+) channels have been found in data to be implicated in the control of the M phase by means of regulating the expression of cyclin B1 through the p38 MAP Kinase, as shown in Fig. 7 [21].

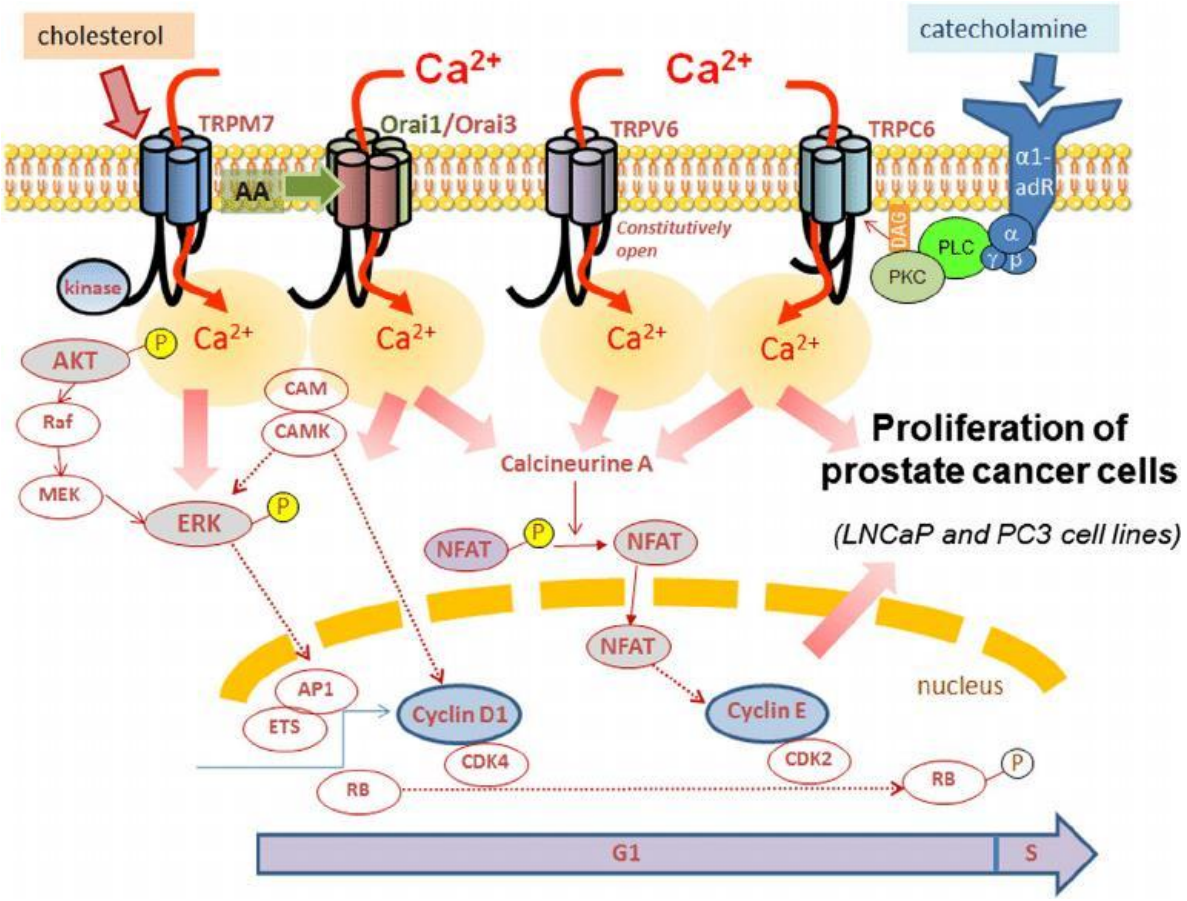

Fig. 7 Alterations and Proliferations in Cell cycle (Source: Massagué, J. 2004).

The question is, which ions or proteins are responsible for maintaining ionic transport balance for the control of cell cycle? It is proposed earlier in the articles, that Ca++ oscillations have a crucial role in the control as a "life and death signal" [22]. Later, it was suggested in the studies, that the oscillations also follow and elicit the NKCC and NHE channels for homeostatic perturbations for planned activities of cell intracellular signalling machinery. These oscillations have been said to produce the membrane potential (Vm) changes as a by-product (as they are maintained through the activity of a range of ion channels), which in itself is necessary for proliferation. Besides this, a variety of K+ channels have been implicated in the regulation of proliferation and cell cycle progression. Mechanisms of the activation of many of these channels are currently unknown [23].

As stated earlier in the data, before volume increase, cell proliferation may require transient cell shrinkage initially, which is accomplished by the activation of Cl^- and K^+ channels. As the electrochemical equilibrium activity of Cl^- ions is above the threshold inside the cell, the activation of Cl- channels is responsible for Cl- exit and thus resulting in depolarization. If Cl^- exit is paralleled by active K^+ channels, then there is net exit of KCl salt, responsible for cell shrinkage. Conversely, the cell growth requires an increase in the K^+ concentration inside the cell. The inward rectifier uptake channels of K^+ activate simultaneously with mechanosensitive channels that are activated by the compression in the plasma membrane that has undergone shrinkage, and help in bringing in higher concentrations of K^+ and water, which increase the turgor pressure, which is needed for cell growth [24].

Data from studies confirmed that the Kv10.1 cause a reduction in the current on the cell membrane. The reduced current is known to be associated with the mitosis-promoting factor (MPF- p24) and Na^+. The K^+ concentrations also regulate the entry of Ca^{2+} inside the cell by ensuring that the membrane potential is negative enough to allow the entry of Ca^{2+} [25]. According to the study of Lang 2007, the Kv1.3 channel in conjunction with the KCa3.1 (a Ca^{2+} dependent K^+ channel) works towards the cell growth and proliferation. Ca^{2+}/CaM is required at two points during the re-entry from quiescence, early after mitogenic stimulation and later near the G1/S boundary. Cell volume not only participates

in the regulation of cell function by hormones, but also regulates hormone release. The release of several hormones is triggered by cell swelling, conversely inhibited by cell shrinkage. The link between cell volume and hormone release is ill-defined in the data sets but partially involves cell volume sensitive alterations of cytosolic Ca^{2+} activity [25].

3.2.4 G2/M phase transition

Studies revealed that, once DNA duplication is completed, the cell proceeds towards the G2 phase where it prepares itself for division into two daughter cells in M phase. A series of events, as shown in Fig. 8, beginning with prophase and then prometaphase, metaphase, anaphase and lastly cytokinesis takes place-which divides the cell into two genetically identical copies during the M phase. A clear role, found in literature, of the dynamic distribution of Ca^{2+} and Ca/CaM is seen in S/G2, G2/M and during M phase. Towards the end of M phase, it was found in studies that, Ca/CaM concentrates itself below the membrane and helps cleave the cell into two. Just prior to M phase, DNA damage checkpoint have the responsibility to give a "Go" signal for advancement to checks whether the DNA is intact or has any mutations to repair. A study by Sanchez et al., stated that it would be catastrophic if cell proceeds to divide with the damage. Studies also revealed that, during G2, mammalian Cyclin B/CDK2 complexes are held in an inactive state by phosphorylation of CDK1 at the two negative regulatory sites, threonine 14 (Thr14) and tyrosine 15 (Tyr15) [26].

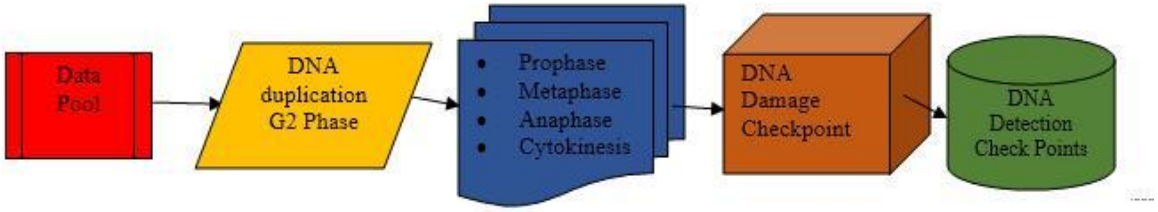

Fig. 8. Data collected through machine learning on G2/M Transition

The data suggested that a study by Kahi et al., 2003, the Ca^{2+}/CaM is implicated in the G2/M transition, M phase progression, and exit from mitosis. During the M phase the MPF increases the selectivity and rectifies the current, promoting the loss of K^{+} from the cell. Moreover, calcineurin was found as Ca^{2+} waves regulators in G2/M transition. Another prevalent enzyme, in addition to cdc25, CAMKII is found as important for G1 progression and G2/M transition. As demonstrated in glioma cells, a drastic volume decrease (or distribution per se) occurs during the M phase to reach a preferred volume state in the division. This relates to the chromatin and cytoskeleton condensation and depolymerization in M phase [27].

3.2.5 Role of Ca2+ in cell cycle

There are a number of different classes of calcium receptors, found in literature through machine learning, which play a crucial role in the maintenance of cellular homeostatic conditions and regulation of cell cycle by mediating the entry and exit of the calcium ions and also stimulating the intracellular release of calcium. Even it was found that the endoplasmic reticulum has calcium receptors, which help in storing calcium and releasing it as and when needed inside the cell during the cell cycle. The detailed classes of calcium receptors were reported by the data which includes the Voltage Gated Calcium Channel (VGCC) which is itself comprised of three different families of receptors, including the Cav1, Cav2 and Cav3. The other classes of calcium receptors include the Receptor-Operated Calcium Channels (ROCCs), the Ryanodine Receptor (RyR) present at the endoplasmic reticulum and the Inositol-1,4,5-trisphosphate receptor (IP3R), as shown in Fig. 9 [28].

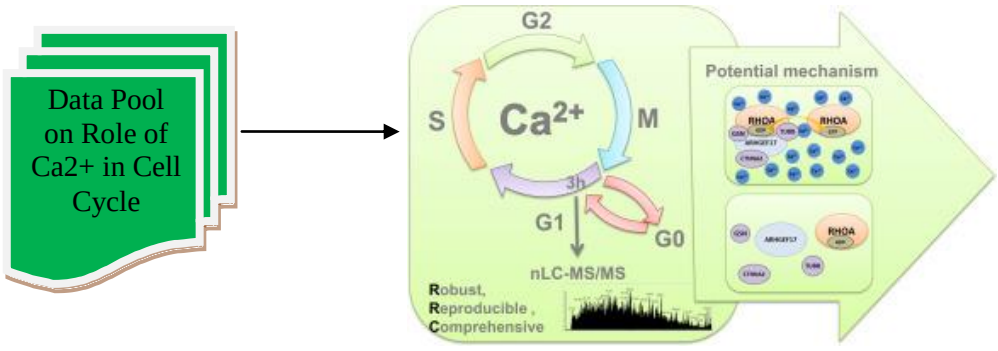

Fig. 9 Role of Ca2+ in Cell Cycle (Source: Villalobos et al., 2001)

Data collected through machine learning showed that, the Ca^{2+} channels control and regulate the cell cycle. In excitable cells such as the muscles, neurons and the endocrine cells, voltage gated calcium channels are used for the entry of Ca^{2+}. The increase in Ca^{2+} concentration inside the cell leads to the phosphorylation of the Mitogen-Activated Protein Kinase (MAPK), ultimately leading to the progression of the cell cycle. The downstream processes following the entry of Ca^{2+} ions are diverse and include expression of a number of different genes, depending on the cell type. The concentration of Ca^{2+} in the resting stage of the cells is very low (around 10-7 M), while in the calcium stores such as the endoplasmic reticulum and the extracellular matrix, Ca^{2+} concentrations are much higher (around 10,000 times higher, approximately 10-3 M). The maintenance of this gradient is ensured by the efflux of calcium from the intracellular organelles [29].

It was also confirmed in articles [27-30] that, Ca^{2+} interacts with the Cyclin-Dependent Kinases (CDKs) to regulate the cell cycle. The CDK family is considered to be important in the transition of the cell through the different phases of the cell cycle and also in the maintenance of the different phases. As the data suggested, CDK4 and CDK6 are found as important in the G1 phase, CDK2 is important in the G1 as well as the S phase, and also speculated to be a part of the M phase, while CDK1 is predominantly reported to be important in the M phase. Ca^{2+} in complex with Calmodulin (CaM) interacts with the CDKs and controls their activity throughout the cell cycle. Ca^{2+} and CaM together regulate the expression of the CDK1, CDK2 and the Cyclin B in human cells (particularly reported in the T lymphocytes). Moreover, it was found that the activation of the stored Ca^{2+} (SOCE: Store Operated Calcium Entry) activates CaM protein, which in turn leads to the blockage in the activity of Cyclin A and E [30].

According to the study of Se et al., 2004, Ca^{2+} oscillations also play a role in the gene expression. This has been documented in the case of the early and late gene expressions in the G1 phase. In the early phase of G1, Ca^{2+} affects the expression of the Serum response element (SRE), the Cyclic AMP Response Element (CRE), MYC, JUN and FOS genes, which are all important for the proliferation of cells. The activity of Ca^{2+}/CaM leads to the activation of CDK4/Cyclin D1 complex, which is involved in the regulation of the retinoblastoma protein (RB1), which is one of the main inhibitors of the DNA synthesis process. The RB1 is found as responsible for interaction with T2F transcription factor for the inhibition of cell cycle. However, the regulatory activities and the phosphorylation of the RB1 protein leads to the transition of the cell cycle from the G1 to S phase. According to Se et al., 2004, this transition is mediated by the regulatory activity of Cyclin D1 and the Ca^{2+}/CaM pathway. Here, the RB1 is inhibited and the p21 and p27 (better known as CDKN1A and CDKN1B) are also negatively regulated [31].

Next, the role of Ca^{2+} has been reported in the transition from G2 to M phase. It has been seen that Ca^{2+}/CaM regulate CAMKII in the G2 phase [59] and lead to the CAMKII mediated phosphorylation of the Microtubule Associated Protein 2 (MAP2), which leads to the inhibition of the microtubule polymerization [32].

4. Advancements in Cell Cycle Modelling

Mathematical modelling and simulation of the cell cycle started a couple of decades ago. This includes, high throughput screening, modelling and simulations, topological interactions for the prediction of the system function and many others. None so far included the machine learning processes, including the training and test sets. No doubt, the engineered models share a systems level approach for biological systems and elucidate an advantageous picture of cell cycle framework and predictions, but a comprehensive illustrative picture is still missing.

We also applied machine learning on computational modelling performed in last 2 decades. The data revealed that Li et al. (2004) were pioneers among others for modelling the complete yeast cell cycle from regulatory proteins [33]. They investigated the global dynamicity and cell cycle proliferation drivers' trajectory and concluded that the network is robustly stable for conducting its functions and declared G1 as a global attractor from simulation dynamics, and that it is stable against all perturbations. Later, Davidich et al. (2008) presented a Boolean network model of the cell cycle sequences which was solely based on the biochemical topology of the interactions reproducing the biological cell cycle time sequence of protein activations. This minimalistic approach boosted the idea of predicting dynamical features of proteins along with protein interaction networks of cell cycle. Furthermore, data suggested that in subsequent years, Mangla et al. (2010) worked on synchronous models of the Budding and Fission yeast cell cycle and concluded that the timing and robustness can be used as the basis for a testable hypothesis that could account for several needs-based refinements in the model [33].

In addition to that Faur é et al. [34] were among the pioneers to model the mammalian cell cycle. They used the most prominent drivers of the cell cycle machinery, i.e., Cyc D, E, A and B along with other regulators and effectors, e.g., P27, Rb and E2F. Their synchronous and asynchronous Boolean modelling demonstrated the asymptotic behavior of the regulatory proteins based on the experimental data and provided the biological justification for using multilevel variables in future research.

Lately, Abroudi et al. (2017) published a paper on 'A comprehensive complex systems approach to the study and analysis of mammalian cell cycle control system in the presence of DNA damage stress'. They even considered G1-S and G2-M checkpoints unlike Faur é et al. [34]. They first refined the published research on ODE mathematical models and then included sub-systems, i.e., growth factors (GF), DNA damage, and G1/S and G2/M checkpoints. As advised by Magla et al. [35], they applied a multi-level systems approach. The model was also used to assess the efficacy of

DNA damage checkpoints in correctly arresting damaged cells and avoiding incorrect arrest of healthy cells and results revealed 98.6% accuracy in correctly releasing healthy cells through checkpoints. Using ANN all of these models can be computed completely and precisely in different layers, as shown in Fig. 10.

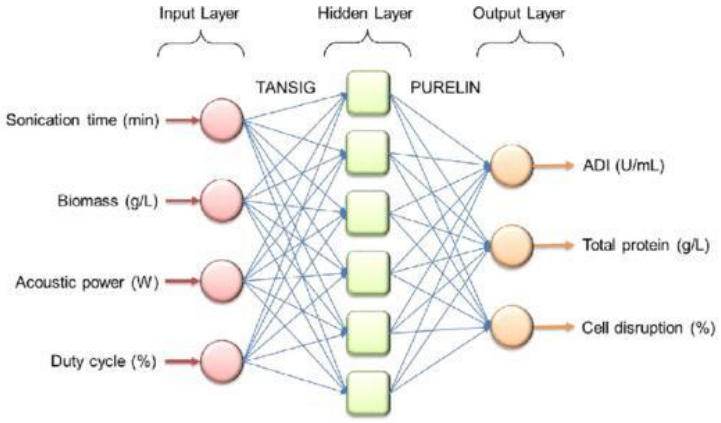

Fig. 10 Cell cycle modelling through ANN

Recently, Castro et al. (2019) developed an agent-based model of cell cycle adhering to the view that kinetic parameters are a crucial aspect when studying reactions involving proteins in real cell cycle [36]. They compared the results to a Boolean network model and found similar results in terms of following the correct sequence of phases. This model could be a starting point for being used in the development of cancer drugs by adding cell cycle mutations that match a specific type of tumor cell cycle and an agent representing the medication or treatment. Recently, Laomettachit et al. [37] applied different mathematical modelling approaches including Boolean, discrete (stochastic), ODEs and hybrids, as shown in Fig. 11, and concluded the same as previous in terms of cell robustness and stability, although their models lacked the technical sophistications for mutated cell cycles.

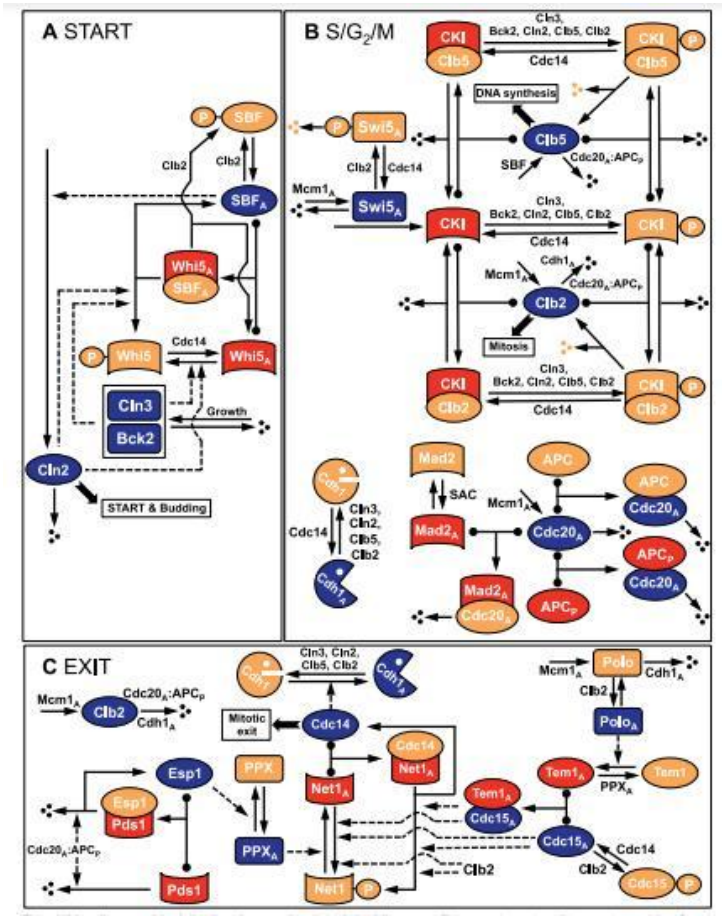

Fig. 11 A cell cycle model by Laomettachit et al.

Scientists are working hard in order to model a cell cycle in a best possible way. As for now the models are quite complicated. Microbiologist, botanists, and zoologists are working to model the cell cycle. Similarly, scientists in the field of artificial intelligence are also trying to compare all models of cell cycles through machine learning [38-40]. The use of innovative technology such as machine learning and Artificial Intelligence will help efficiently to model the cell cycle using data of recent research [41,42].

5. Conclusion

The proliferative process of cell is important, and it has aided in research studies related to different areas of biological sciences. Data derived through machine learning indicates that our current comprehensive understanding of cell cycle is lagging and therefore, it requires the utilization of Artificial Intelligence in this domain so that mathematical algorithms and machine learning techniques could be applied to sort the huge volumes of data. This study was conducted with the same aim to demonstrate the role of different unconventional players that are actively controlling cell cycle. It has been observed in our study that though a significant attention has been given to conventional genomic regulators of cell cycle and their participation in different disease conditions have also been evaluated, but a clear picture of mechanism of action of these unconventional players is still missing. Thus, we have identified some key volume regulatory control elements in our study and presented the work that has been done on them to better understand the process of cell cycle.

In order to efficiently evaluate our current progress in the field of cell biology, computational biologists are working hard to identify different regulatory components of cell, its processes, machineries and cell cycle and combining them to develop a computational model so it could aid in better understanding of the process along with predicting the effects of perturbations that may be associated with any pathological condition. Different computational tools were being used in these studies and computational models were built for different cellular processes of both prokaryotic and eukaryotic cells. But our study through machine learning by using neural networks has found that though, a lot of work has been done on cell and cell cycle, but we still lack an all-inclusive picture of cell cycle model. Therefore, the unconventional players identified in our study would enable researchers to improve the current models of cell cycle by incorporating more regulatory elements in them.

As previous computational models of cell cycle have not considered the importance of inclusion of volume regulatory control elements in cell cycle, therefore, our work will provide a basis to improve the current knowledge available on cell cycle through artificial intelligence. It would help in developing a comprehensive cell cycle model by incorporating as many details as possible in the simplest possible way so that it could assist biologists in identifying and evaluating the effects of perturbations in pathways. It will help in evaluating the role of various drugs on regulating membrane potential, ionic homeostasis in the microenvironment and volume regulation in wet lab so that new targets could be identified and their efficacy could be determined. Our study demonstrates that researchers need to emphasize on volume regulatory machinery as well by identifying their mechanism of action and their utilization in therapeutics. It would ultimately shift a focus from genome regulatory components to volume regulatory elements and if it will work well, it would enable us to overcome the effect of Multi Drug Resistance (MDR). The jump from wet lab experimentation to computational modelling has proven vital. There is now a need to take a leap towards machine learning and artificial intelligence methodologies to better understand the working of the cell. Together, these phenomena may pave the path for bringing innovation in the field of regenerative medicine and to develop new therapeutic solutions to prevent or restore disease states such as uncontrolled cell proliferation in cancer.

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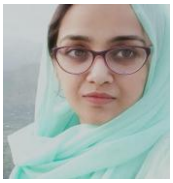
Authors' Profiles

Mustafa Pasha is an independent consultant on computational modelling and simulation on medical and health related topics. He has a master's in computational sciences and engineering from NUST, Pakistan and a PhD in Applied computing from Lincoln, New Zealand. He has a dedicated set of expertise in drug design and discovery, his past work includes work on cancer cell proliferation and human cell cycle modelling and simulation. Besides his research profile, he has number of achievements in health business, procurement, and novel solutions consultations. He holds the privilege to be nominated in Canterbury Business Champion, New Zealand. His research interests include, Pharmaceutical Formulations, Intelligent Modelling and Simulation, Artificial intelligence, Machine learning, Data Analysis, Industrial Business Consultancy and regulatory affairs.

Khurram Munawar is a PhD student at the Lincoln University (New Zealand) He is a multi-disciplinary researcher with experience in Computer Visualization, machine learning, computational sciences, computational modeling and artificial intelligence, he has several international publications in various journals and conferences and has actively been working in Visualization and Artificial Intelligence domain.



Asma Talib Qureshi is a MS student in the Healthcare Biotechnology discipline at NUST, Pakistan. She has also been a member a Pakistan Society of Basic and Applied Neurosciences. She has expertise in biotechnology, cancer research and neurosciences. She has worked on autoimmune and viral diseases and currently her main area of research interest is cancer biology and nervous system disorders.

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A Method to Detect Breast Cancer Based on Morphological Operation

Prashengit Dhar
Department of Computer Science and Engineering, Cox's Bazar City College, Bangladesh
E-mail: nixon.dhar@gmail.com

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Abstract: Breast cancer is one of the most common cancer in women worldwide. Early detection of breast cancer can lead to better treatment and decrease in mortality. Mammogram image in medical technology, made it easier to analyze breast cancer. Mammography exam is a specialized imaging technique in medical to scan breast which results in mammogram image. Detecting breast cancer earlier, a patient can have several treatment options and also can save live. Early detection of breast cancer can leads to survive 93 percent or greater in the initial five years. This paper proposes a brseast cancer detection method from mammogram image sample by applying morphological operation on gray image rather than binary. Firstly, image is sent for gamma correction. Then it is converted to gray and applied morphological dilation. Again morphological opening operation is formed on the dilated image. Output of dilated and opening operation is then binarized. An AND operation is performed between both binary images. Some post processing like-small area filtering and hole filling task is took place. Then common unwanted object is removed. Finally rest of the region is the desired cancer infected region. Achieved performance is acceptable and satisfactory through the proposed method.

Index Terms: Mammogram image, breast cancer, dilation, opening, detection

1. Introduction

Beast cancer is generally considered as a major reason of death due to cancer in women. Both male and female can be suffered from this, but in most of the case it is often found in female over 40 year[2]. It's a challenging task to detect cancer region from mammogram image of breast and also it may not be possible to detect exactly accurate region. However early detection is a necessary step to reduce risk in treatment. A specialized medical imaging named mammography uses low-dose x-ray method to scan the breasts. Mammography exam output which is mammogram image, helps in early detection as well as diagnose too [1]. Screening mammograms are directed to find breast cancer in women without apparent indications. Breast tumors are gradually increases in size with time. A breast tumor generally takes four to five years to reach 1 mm, around two years to reach at 5 mm and more than one year to be 2 cm in size [5,6,7,8]. The aim of thi research is to locate the cancer region. Using the power of morphological tools, breast cancer detection is presented in this study. Cancer regions can analyzed better in mammogram images. With the presence of nodules, indicate the symptom of cancer. Analyzing mammogram images, provide much information and knowledge about breast cancer region.

In this study, morphological application based breast cancer detection is focused. Dataset named MIAS mammography from kaggle is used in this research [18]. Section III contains an overview of proposed method. Morphological operation involved in this research is discussed in section IV. Complete detection strategy is detailed in section V. Finally, conclusion is in section VI.

2. Related Works

For detection, segmentation of image is an effective way to reach at goal. Basically, segmentation partitions an image into several components or objects. Various ways are exists to segment image [3,13]. Double thresholding method for segmentation is a basic way to segment image. [4]. Samir used double thresholding approach for detecting cancer cells in breast [9]. . A mask is applied after performing D-thresh. The whole method also reduces storage area of processing. Mustafa proposed segmentation for breast cancer using GVF snake technique. [11]. Noise is removed using low pass Gaussian filter and then GVF snake technique is applied to find cancer regions. Bacterial foraging technique is used by Dubey for breast cancer detection [10]. It is followed by multi level thresholding. Basheer proposed method to

segment mass using texture analysis [16]. Also adaptive median filter was employed. The adaptive median filtering helps in contouring image. After that using texture properties of the resultant ROI, required contour is selected.

ML algorithm based detection method is also used by researchers [10] . Abdul proposed SVM algorithm based breast cancer detection method from mammogram images [12]. With the help of texture analysis an SVM, Eddaoudi proposed a method to detect masses. [14]. Sampaio presented a method to detect masses from mammogram image [15]. It removes noise and object beyond boundary. So as internal breast structure is then highlighted. Neural network is used to segment mass. Then shapes are analyzed. Then candidate regions are classified with support vector machine. Wavelet transform and k-means clustering based segmentation is proposed by Dalmiya [17]. Discrete wavelet transform is employed to get max details from MRI images. Sharpness is achieve by adding the output image with original input image. K-means clustering is executed on sharpened image for locating tumor region. Finally, thresholding took place on clustered image to extract tumor region. In this paper, a breast cancer detection method is proposed. Proposed method is mainly based on morphological operations.

3. System Overview

This paper presents a system of morphological based breast cancer detection. This section provides a n overview of proposed system. Fig.1 shows the steps involved in proposed breast cancer detection. Input image is enhanced. For this purpose gamma correction of input is processed and results in an enhanced and suitable form. Dilation task is performed on gamma corrected gray image. Dilation expands contained shape of image. Then morphological opening is performed. Opening is erosion of image and dilation of that eroded image. Binary form of dilated image and opening output is created. Both the binary image is considered for AND operation. Distinctive small areas are filtered .To more fine the image, holes are filled. To get the cancer cell region, common unwanted object located at top is cleared. Rest of the images is considered as cancer cell region as well as breast cancer region. Brief description of these steps is described in section V with example.

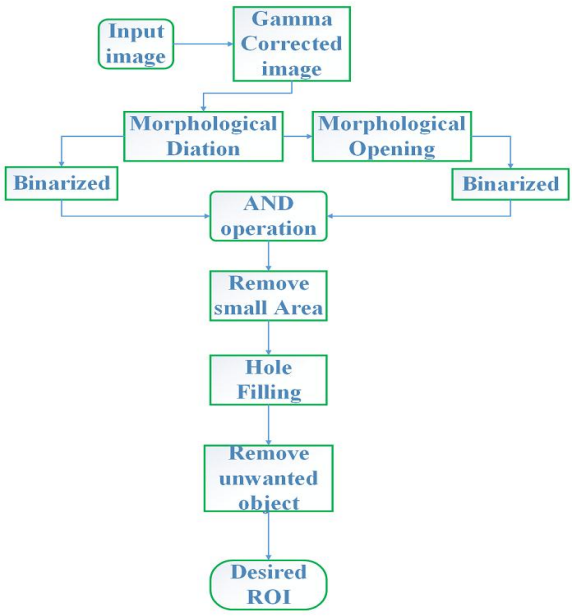

Fig.1. Flow of proposed detection system

4. Morphlogical Opeartion Overview

Most common and primary operation of morphological tasks are dilation and erosion. This study considers dilation and opening operation as morphological application. Opening operation is combination of both erosion and dilation. Morphological tasks covers core step in this research.

A. Dilation

Dilation is a basic morphological operators used in image processing. It is normally functional to binary images, but also works on gray image. The main outcome of the dilation operator while using on binary image is to progressively broaden the boundaries of foreground pixel's (white pixels). region. Therefore, areas of white (foreground) pixels propagate in size while holes lies in those area become smaller. In dilation, the operator takes two

portions of data in place of inputs. The first one is the image which is needed to be dilated. The another is structuring element (typically small) which is a set of coordinate points. It also known as kernel. The second one i.e structuring element defines the particular effect of the dilation on the image. Fig.2 is a structuring element of 3x3 size.

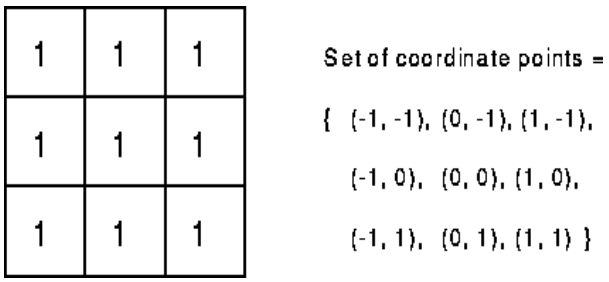

Fig.2. Structuring element of size 3x3

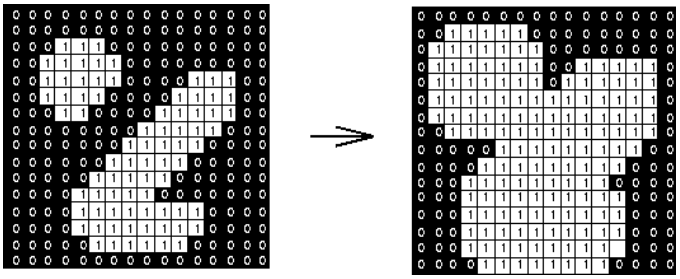

Fig.3. Dilation effect of using 3x3 structural element

The structuring element of fig.2 is applied on fig.3 (left) for dilation. The result is in fig.3 (right). The dilation operator works like fig.4 on binary image.

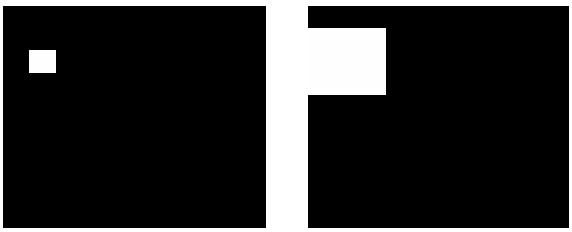

Fig.4. Before (left) and after(right) dilation

The idea behind grayscale dilation is similar to binary with the exception of the way in which the kernel related with the input image is derived. In that case, these kernels are 3-D rather than 2-D.

Grayscale dilation with a structuring element normally brights the image. Bright regions bounded by dark regions enlarge in size, besides dark regions bounded by bright regions compress in size. Minor dark spots in images vanish as those are filled in by surrounded intensity. Small bright spots becomes larger. Fig.5 shows a vertical cross-section of a gray-level image and the effect of dilation using a disk shaped structuring element.

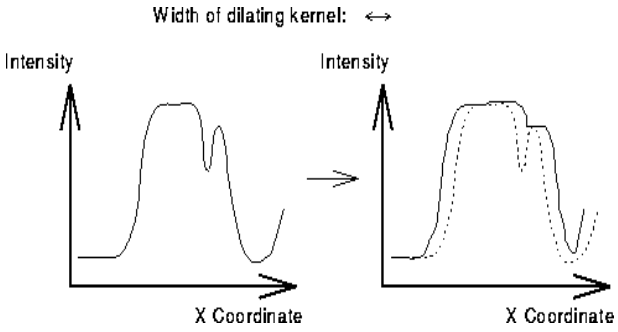

Fig.5. A cross-section (vertical) through a gray level image

B. Erosion

As like dilation, erosion operator requires two input data. One is the image and another is a (typically small) kernel or a structuring element. It is this structuring element makes the effect of the erosion on the image. Fig.2 depicts how erosion works using same structuring element of fig2.

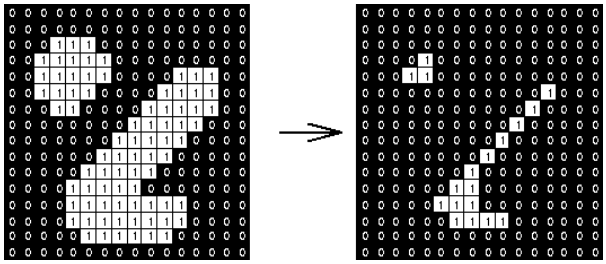

Fig.6. Effect of erosion

C. Opening

In simple form, opening refers to erosion which is followed by way of dilation keeping the same kernel or structuring element.. Like dilation, opening operator also demands two inputs. One is the image (to apply opening operation) and another is the kernel or structuring.

Similarly, gray level opening involves gray level erosion followed by gray level dilation. Effect of opening operation is shown in fig.7 as an example. Fig.8 shows effect of opening on a binary image.

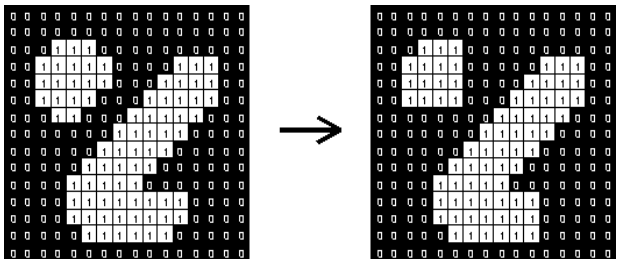

Fig.7. Opening operation

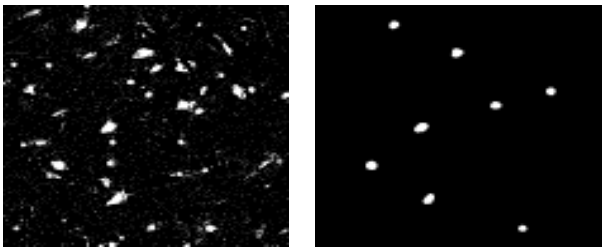

Fig.8. before (left) and after (right) opening

5. Detection

Detection of breast cancer is usually means to identify cancer cell regions. In this system mammogram images are considered to detect breast cancer. Mammogram images are suitable to detect breast cancer through image processing technique. Cancer infected regions are dense white pixels in mammogram image. The proposed system initially enhanced the input image by gamma correction. Fig.9(a) is the input image and fig.9(b) is the gamma correction. This gamma correction step is very useful for further processing. It makes the input image more flexible to detect cancer. Then the image is converted to gray. A very popular and common morphological technique named dilation is applied on the gray image. Dilated output is displayed in fig.9(c).

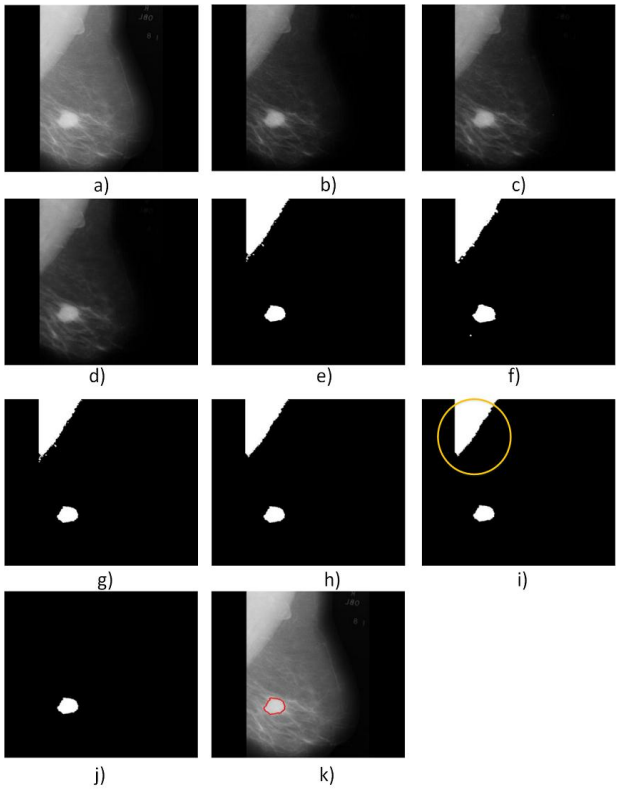

Fig.9. Results of breast cancer detection steps a) input image b)gamma corrected image c) dilated image d) output of opening on dilated image e) binarization of dilated image f) binarization of opening image g) AND output h) small area filtered image i)hole filled image j)removed unwanted and desired roi k)marked detected region

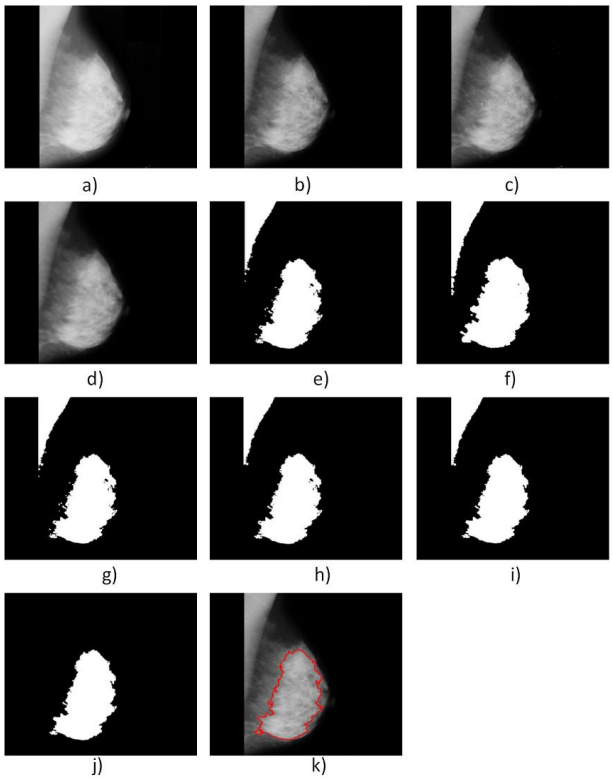

Fig.10. Results of breast cancer detection steps a) input image b)gamma corrected image c) dilated image d) output of opening on dilated image e) binarization of dilated image f) binarization of opening image g) AND output h) small area filtered image i)hole filled image j)removed unwanted and desired roi k)marked detected region

Dilation is the way of expanding white pixels and reducing black pixels. It increases foreground area while decreasing background. After that opening operation is formed again on the dilated image. Principle behind opening technique is erosion task followed by dilation. Fig.9(d) shows result of opening operation. Later output of dilated image and opening image is transformed into binary image. Result shown in fig.9(e) and fig.9(f) respectively. An AND operation is applied between the two binary image. Thus it keeps the common pixels and removes other. Output of AND operation contains cell region and some noises. AND output displayed in fig.9(g). Small area based filtering is then employed on AND output. Then holes are filled. Fig.9(h) fig.9(i) are the area filtered and hole filling output. An unwanted object is usually exists at the top. Object at top position of image is considered as unwanted object. . First object returned by bounding box is usually unwanted object considered in this study. The object is circled in fig.9(i). Finally, that object is removed using bounding box parameter. Result is in fig.9(j) and it is the detected breast cancer region. A visualization of detected region is marked on input image. It is shown in fig.9(k). Few examples are also shown in fig.10 and fig.11.

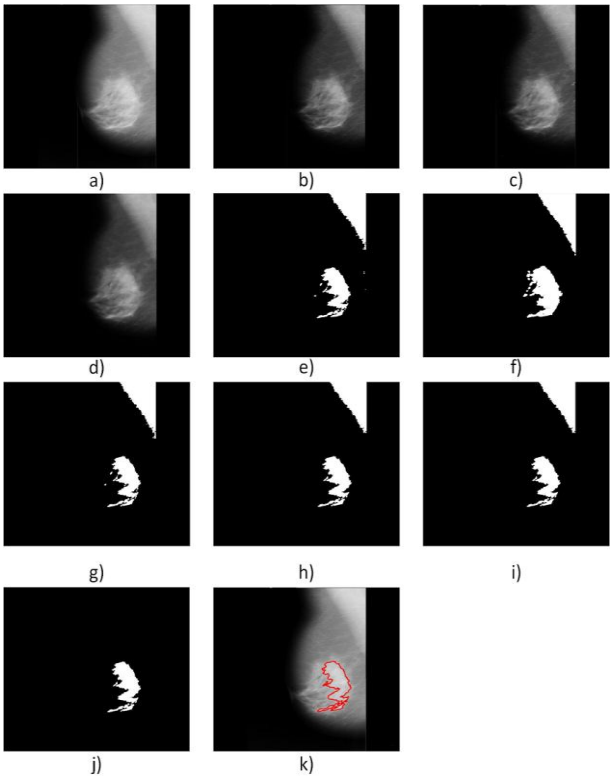

Fig.11. Results of breast cancer detection steps a) input image b)gamma corrected image c) dilated image d) output of opening on dilated image e) binarization of dilated image f) binarization of opening image g) AND output h) small area filtered image i)hole filled image j)removed unwanted and desired roi k)marked detected region

6. Conclusion and Future Work

Every year a significant number of women are dies for the reason of breast cancer. Mammogram image depicts well output of breast scanning. Early detection of this cancer is hardly needed to reduce death and also risk of treatment. This detection method can be helpful in medical field. A computerized system can check for cancer regions within short period of time. This paper elucidates a method for breast cancer detection from mammogram images. Multiple morphological operation is processed in this study which results satisfactory. Gamma correction of the image proves better for additional processing. It also has a good effect in detecting cancer. However various issues are yet to solve for more better performance like contrast enhancement, segmentation and also standard dataset is also a issue. Combination of different methods will be analyzed in future as hybrid technique to get more efficiency and much reliability in detection of breast cancer.

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Author's Profile

Prashengit Dhar received his B.Sc. degree in Computer Science and Engineering from University of Science and Technology Chittagong (USTC) and M.Sc. degree in Computer Science and Engineering from Port City International University. Currently he is working as a lecturer in a college. He has published many papers in conference and journal. His research interests include image processing, pattern recognition and machine learning.

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Object Motion Direction Detection and Tracking for Automatic Video Surveillance

Adithya Urs[1], Dr. Nagaraju C[2]
1 Student Dept. Of ECE, 2 Assistant professor, Dept of ECE, The National Institute of Engineering, Mysuru, India
Email: adithya.s.urs@gmail.com

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Abstract: In today's world having a smart reliable surveillance system is very much in need. In fact in many public places like banks, jewellery stores, malls, schools and colleges it is basic necessary to have a surveillance system (CCTV). Most of today's implementations are not smart and they record videos during night even when there is no motion. This will lead to unnecessary storage usage and difficult to get the important part of the footage. And also, most of the today's implementations are stationary, they can't track the moving object. This report will outline a naive approach to implement a smart video surveillance system using object motion detection and tracking. Here we are using conventional Background subtraction model to detect motion and we estimate the direction of motion of object by comparing the centroid of the moving object in subsequent frames and track the moving object by rotating the camera using servo. Video recording takes place only when there is movement in the frame which helps in storage efficiency. We are also improving the speed of email alert delivery by using multithreading.

Index Terms: Background subtraction Contours, Convolution, Dilation, Erosion, Gaussian blur, Multithreading.

1. Introduction

Security has become a major concern in third millennium. Due to the increasing population and business of cities it is very difficult to monitor each and every person. At night monitoring the activities of each and every room in a huge building manually is difficult and tedious task. Here we are presenting a novel approach of motion tracking and object detection in video footage which take action based on the motion of any foreign objects into the video frame and also tracks the direction of movement of the object and move accordingly. In most part of the world they relay manually for intrusion detection. Some of the existing automatic surveillance systems use infrared sensors which detects intrusion by using two IR sensors in adjacent position and based on which sensor activates first the direction of motion can be predicted. This system can only detect motion but is highly unreliable when determining the direction of object

The other approach used today is by using PIR sensor. When the sensor is idle, both slots detect the same amount of IR, the ambient amount radiated from the room or walls or outdoors. When a warm body like a human passes by, it first intercepts one half of the PIR sensor, which causes a positive differential change between the two halves. When the warm body leaves the sensing area, the reverse happens, whereby the sensor generates a negative differential change. These change pulses are what is detected. The disadvantages of PIR sensors are they are easily interfered by heat sources. And sensitivity decreases when ambient temperature is equal to human body temperature

None of the existing automatic surveillance system can detect the identity of the intruder and also has the above Drawbacks.

Using CCTV can get the identification of the intruder but it needs continuous manual supervision. And also, the image based automatic intrusion detection system used today can detect motion but fails to automatically track the moving object.

Our approach is to use the camera footage and process it to detect direction of motion. And move the camera according to the direction of motion of the object. This is done by getting the directional information and steering the servo (which hosts the camera on top of it) using a micro-controller. We are also recording the footage only when object is detected which will increase storage efficiency. Speed of alerting is also improved by using multithreading over SMTP API.

Open CV is an open source library for image processing and Computer vision applications, is having the predefined library of various required essential operations as methods. So, we choose Open CV and Jupyter Notebook as the IDE for development.

2. Literature Survey

[1] Yongxiang Wu, "Research on bank intelligent video image processing and monitoring system based on Open CV"

This paper accomplishes the task of real time surveillance using human detection, Motion tracking and behavior judgement even here background subtraction method is used. The system developed can accurately judge motion and human detection helps in avoiding false alarms.

[2] Neha Gaba, Neelam Barak and shipra Aggarwal. "Motion Detection, Tracking and Classification for Video Surveillance"

Here frame differencing method is used in which background is modeled first and is used as a reference based on which motion is detected.

[3] Khirod Chandra Sahoo; Umesh Chandra Pati "IoT based intrusion detection system using PIR sensor".

Simple cost effective, Iot based always connected to internet so it is very effective in alerting. Use of PIR sensor helps in detecting even in dark environment. But fails to identify the intruder.

Each of the existing surveillance system detects motion but fails to identify the direction of motion and track the moving object. Our main research objective is to detect the direction of motion, also a storage efficient system. Our secondary objective is to improve the speed of email alert delivery in an intrusion detection system.

3. Proposed Methodology

Our approach for accomplishing the above objective is as follows, we are using background subtraction, which is quite simple model where two subsequent frames of video feed is subtracted to check for difference. This difference helps is detecting motion. On the differential frame we are applying Gaussian blur, Erosion and dilation to enhance the clarity of the moving object. The reasoning behind the usage of the above operations is given in the later section. After estimating the moving object, a contour is drawn around it. The centroid of the object is calculated. Now the relative position of the centroid of the object in subsequent frames gives the directional information. We are using a look-up table stored in the memory to map the angle of rotation of servo with the position of the object. Pyserial library is used to send the positional information of the object from the host computer to micro-controller through serial communication. Email alert delivery which is done by the host computer is improved by using multithreading to get real time performance.

4. Hardware and Software

1. Hardware Requirements:
Hardware we used to develop the module is as listed below.

Processor	:	Intel 8th gen i5
RAM	:	8GB +
Hard disk space	:	1TB +.
Controller	:	Arduino UNO
Sensor	:	Standard 720p HD Camera
Steering device	:	Standard metal gear servo

2. Software Requirements:
Software required in development is as listed below

Operating System	:	Windows 7 or Higher
Language	:	Python 3.7
Library	:	OpenCV
IDE	:	JUPYTER
Com Protocol	:	Pyserial

5. Algorithms

The above model works on the principle background subtraction which is a very simple but also a very effective model at the same time. Background subtraction was used because it is computationally inexpensive can be run on portable devices and also gives fairly reasonable result.

A. Background subtraction

This is a quite simple model where subsequent frames of a video are captured and then they are converted to Grey scale and then corresponding pixel of first image is subtracted from the next image. After that each pixel of that corresponding image is compared to a per-set threshold value and if the value is greater than the threshold value it is

considered as one else it is considered as zero by this way a binary image is formed. This binary image gives the data about the motion of object in the frame. The equation for the above operation is shown in equation 1 below.

$$|P[F(t)]-P[F[t+1]|>Threshold \quad (1)$$

B. Gaussian blur

Next Gaussian blur is applied which is basically used to reduce the noise of the image. Blurring the image in the sense it also reduces the details of the image but the reduction of noise over weighs the reduction of detail and hence it is used. Gaussian smoothing is also used as a pre-processing stage in computer vision algorithms in order to enhance image structures at different scales. Mathematically, applying a Gaussian blur to an image is the same as convoluting the image with a Gaussian function. The Gaussian function is defined in equation (2).Here x,y represent the pixel coordinates and G(x,y) represents the function.

$$G(x, y) = \frac{1}{2\pi\sigma^2} e^{-\frac{x^2+y^2}{2\sigma^2}} \quad (2)$$

C. Erosion

Erosion (usually represented by $\ominus$) is one of two fundamental operations (the other being dilation) in image processing from which all other morphological operations are based. It was originally defined for binary images, later being extended to grayscale images, and subsequently to complete latices. Here we take the given binary image as input and a kernel/mask image of specific size. In our case it is a 5*5 matrix of unity matrix and then mask the entire image to get the output. The below equation indicates that erosion of matrix A and B is the set of all points z such that B translated by z contained in A. Erosion is used to remove insignificant portion of the binary image like fluctuations, change in lighting condition.

$$A \Theta B = \{ z \in E \mid B_z \subseteq A \} \quad (3)$$

D. Dilation

Dilation is the process of magnifying a particular recognized object in the image this is done this algorithm is similar to erosion but here when comparing the kernel matrix with the binary matrix even if full match or partial match of kernel with the image happens it is considered as one. Dilation (usually represented by $\oplus$) is one of the basic operations in mathematical morphology. Originally developed for binary images, it has been expanded first to grayscale images, and then to complete latices. The dilation operation usually uses a structuring element for probing and expanding the shapes contained in the input image. The equation for dilation operation is given below. Dilation is used to magnify the significant part of the image i.e. moving object.

$$A \oplus B = \bigcup_{b \in B} A_b \quad (4)$$

E. Contours

After the binary image is processed and contains only the essential information it is now time to find contours. This is nothing but an edge detection algorithm which draws the boundaries around a moving object this is helpful in visualizing the part of the frame in which moving object is detected for this we are using chain approximation which is quite optimistic computationally for this purpose.

After finding the contours it is drawn in every frame of the image and displayed. If no motion is detected an empty array is returned based on this motion detected or no motion detected message is printed. Now that we know about contours, we have to make sure whether the contour is of reasonable size or not for this we find the largest contour in the frame. This is done by comparing the area of each contour in a particular frame. Now the centroid of the contour is calculated by using mid-point formula, a widely used mathematical formula for finding the mid-point of object in 2D plane.

F. Multithreading

We are using the G mail service for connecting to the server attaching the snapshot. The overhead when sending an email can be unpredictable as it depends on many factors like network connection, latency, server availability. So, this may slow down the performance. The system performance fell well below acceptable level due to the overhead of connecting to server establishing connection and sending a mail.

This problem is dealt using multithreading library and concurrently sending the email and processing the incoming stream of images A web-based alerting system was developed using SMTP API to send the mail to alert the user regarding suspicious activities. The average overhead of 1-2sec per 5 frames without multithreading was reduced to

zero latency by using multithreading.

6. Figures and Tabels

In this section we will be presenting the block diagram for all the operation proposed in the algorithm above. Fig 1 presents the background subtraction algorithm. Fig 2 presents all the prepossessing morphological operations. Fig 3 and Fig 4 presents the email delivery system without and with multithreading.

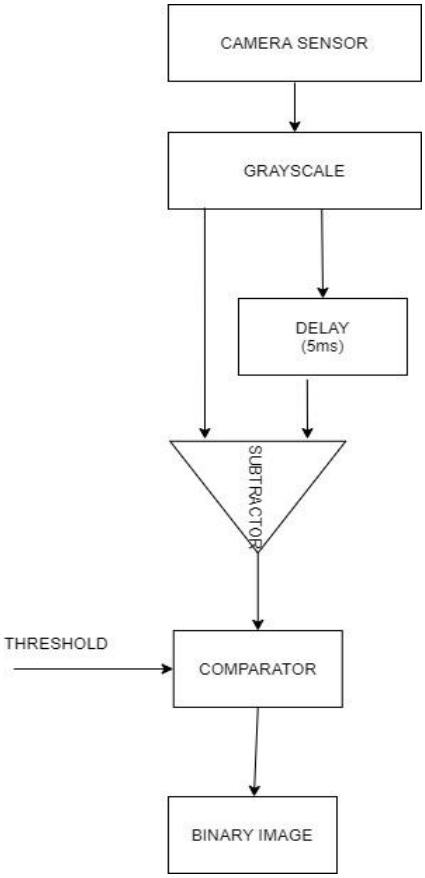


Fig.1. Background subtraction

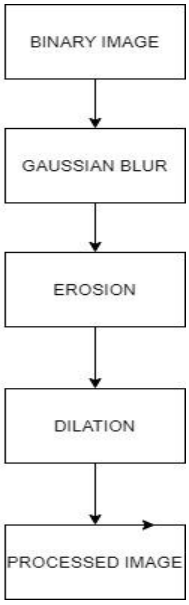


Fig.2. All pre-processing operations

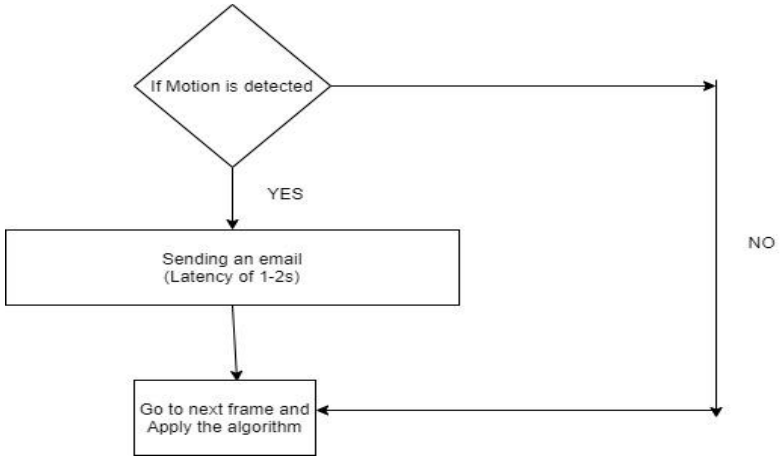


Fig.3. Without Multithreading

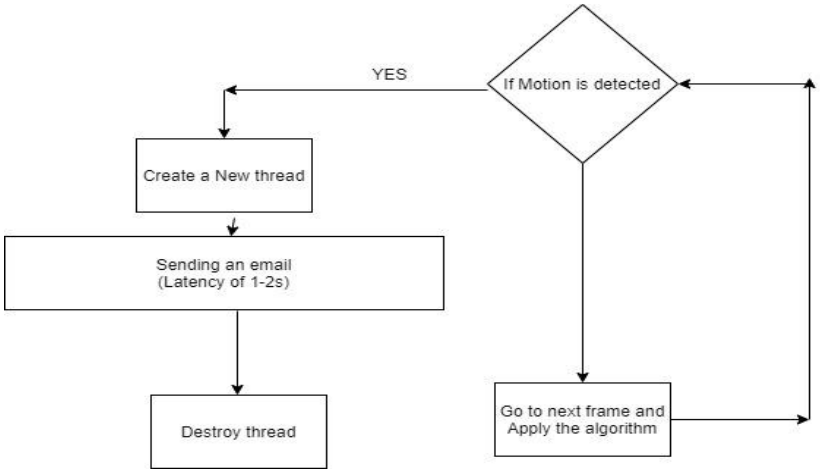
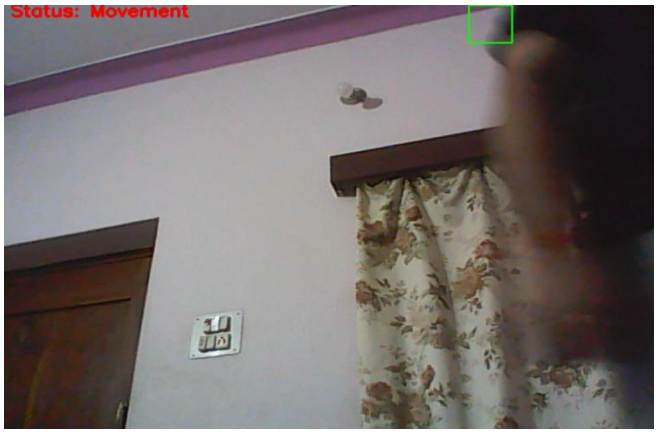


Fig.4. With using multithreading

7. Results and Discussions

A. Motion Detection

We got good results in terms of motion detection; Sensitivity of motion was optimal so it is detected only if significant motion has occurred. The threshold value for pixel variation was kept at 90 to 200 for a max value of 255. And the area sensitivity was about 1400 pixels square for an image of dimension 720*1280 in resolution.



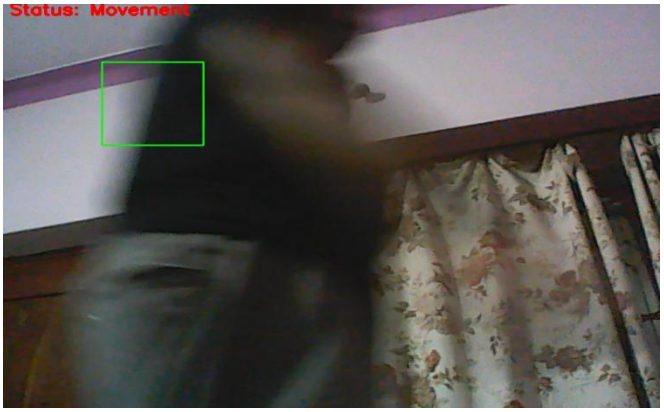


Fig.5. Movement

Fig.6. No Movement

B. Direction detection

Direction detection was implemented by comparing the centroid of the moving object in the subsequent frames if the centroid is greater in the next frame it is moving left else moving right, Due to lots of errors and ambiguity in this method. We mapped the horizontal pixel value of centroid of the pixel value to the angle of rotation of the servo the result of the above is tabulated below.

Table 1

Position of moving object In horizontal	ASCII value of 8-bit serial code	Angle of servo rotation
x<=100	0	170
x>100 and x<=200	1	153
x>200 and x<=300	2	136
x>300 and x<=400	3	119
x>400 and x<=500	4	102
x>500 and x<=600	5	85
x>600 and x<=700	6	68
x>700 and x<=800	7	51
x>900 and x<=1000	8	34
x>1000 and x<=1100	9	17

C. Storage efficiency

Here we got an average efficiency of 20 to 30%. This efficiency will not only serve as a storage solution but also as an easy way of searching only the essential part of the video feed, so easy to find the most required part in the video. Due to the alarming rate in which data is getting generated in today's contemporary world. This serves as a vital aspect of storage efficiency

Table 2

Trial no	Original video size (in MB)	Optimized video size (in MB)
1	10.52	8.38
2	20	15.58
3	5.2	3.52
4	15.4	12.2

Trial no	Efficiency (in %)
1	21.35
2	23.1
3	33.3
4	21.8

8. Conclusion

We have successfully designed and developed a video surveillance system that can track the direction of motion of an object and if two or more objects move simultaneously the object which has the larger dimension will be considered. And if the object is about to move out of the frame the camera moves accordingly so that the object in motion will be in the center of the frame. Also, the camera only records when it detects Motion so that storage redundancy can be eliminated and can be made highly efficient.The email delivery alerting system is also improved by using multithreading.This will advance the existing intrusion detection system to not only detect but track the moving object and also alert the user in real time.

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Authors' Profiles

Adithya Urs completed his B.E in Electronics and Communication from The National Institute of Engineering Mysuru. He has also done 6 months of internship in Robert Bosch engineering and business solution pvt

Dr. C Nagaraju completed his B.E and M-Tech from SJCE, Mysore. He has completed his Ph.D. at PET Research centre, Mandya. He has 15 years of teaching experience and currently working as Assistant Professor, in department of ECE at The National Institute of Engineering, Mysore. He has published more than 30 research publications in various National, International journals and Conference proceedings.

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Predictive Intelligent Decision Support Model in Forecasting of the Diabetes Pandemic Using a Reinforcement Deep Learning Approach

Arnold Adimabua Ojugo
Department of Computer Science, Federal University of Petroleum Resources Effurun, Delta State, Nigeria.
Email: ojugo.arnold@fupre.edu.ng, arnoldojugo@gmail.com, maryarnoldojugo@gmail.com

Elohor Ekurume
Department of Computer Science, Delta State University, Abraka, Delta State, Nigeria
Email: elohorogaga@gmail.com, elohorogaga@delsu.edu.ng,

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Abstract: Diabetes has since become global pandemic – which must be diagnosed early enough if the patients are to survive a while longer. Traditional means of detection has its limitations and defects. The adoption of data mining tools and adaptation of machine intelligence is to yield an approach of predictive diagnosis that offers solution to task, which traditional means do not proffer low-cost-effective results. The significance thus, is to investigate data feats rippled with ambiguities and noise as well as simulate model tractability in order to yield a low-cost and robust solution. Thus, we explore a deep learning ensemble for detection of diabetes as a decision support. Model achieved a 95-percent accuracy, with a sensitivity of 0.98. It also agrees with other studies that age, obesity, environ-conditions and family relation to the first/second degrees are critical factors to be watched for type-I and type-II management. While, mothers with/without previous case of gestational diabetes is confirmed if there is: (a) history of babies with weight above 4.5kg at birth, (b) resistant to insulin showing polycystic ovary syndrome, and (c) have abnormal tolerance to insulin.

Index Terms: Diabetes, Type-I, Type-II, Gestational, deep neural network, modular learning, Silent killer

1. Introduction

Diabetes is a group of metabolic diseases characterized by high levels sugar in blood when the pancreas does not make enough insulin (hormone produced by the pancreas to control blood sugar) – to help its cells respond to insulin normally. The chronic hyperglycemia of diabetes is associated with long-term damage, dysfunction, and failure of different organs, especially the eyes, kidneys, nerves, heart, and blood vessels. Symptoms of marked hyperglycemia include polyuria, polydipsia, weight loss, sometimes with polyphagia, and blurred vision [1-3].

Diabetes set today as a global epidemic and now affects some 300-million people worldwide. It is also estimated that most people who have diabetes know their condition. There are 4 million deaths per year related to diabetes and its complications, representing 9% of world mortality [4]. Diabetes is associated with major socio-economic impact for both the individual and society. Their high costs are mainly related to a high frequency of acute and chronic complications, such as higher incidence of cardiovascular and cerebrovascular diseases, blindness, kidney failure and non-traumatic amputations of lower limbs, which are causes of hospitalization, greater needs for medical care, disability, lost productivity and premature death of life [5-7].

Diabetes prevalence continues to grow and people with this chronic disorder requires continued medical care, support to prevent acute complications, reduce the risks associated with long-term complications and ongoing patient self-management education,. On average, their medical expense approximates to twice higher than regular patient, not including indirect costs due to factors such as absenteeism, reduced productivity, and lost productive capacity due to early mortality [8-11]. Here in this study, we are propose a deep learning model to effectively classify with consistent outcome, early diagnosis of diabetes, combining stochastic rules of the various dataset feats carefully selected via a multi-criteria decision agent-based model to yield a solution that effectively classifies dataset (as well as dataset not present from the outset) into the various diabetes classes (i.e. type-I, type-II and gestational) with marginal error rates.

A. Literature Review

Diabetes mellitus (also known as the ***silent sugar killer***) is a metabolic disorder characterized by presence of hyperglycemia from defective insulin secretion, action or both. This metabolic disease features high glucose level in a body with insufficient insulin to breakdown glucose, or in a body that is resistant to the effects of insulin [2]. To improve its early diagnosis, various studies have used data mining tools to help experts effectively classify the disorder with criteria based on glycemia thresholds associated with micro-vascular disease and especially with the retinopathy. Individuals with diabetes are grouped into: ***chronic*** hyperglycemia (a relatively specific long-term micro-vascular disorder affecting the eyes, kidneys and nerves with increased risk for cardiovascular defect), and ***prediabetes*** (a practical, convenient term for impaired fasting glucose, impaired glucose tolerance or glycated hemoglobin of 6.0% to 6.4%). Both of these classes, places patient at a high risk of developing diabetes [1-2, 12].

Also, [1, 3-7] classified diabetes into: (a) **Type-I** (as prone to ketoacidosis and results from pancreatic beta cell destruction as measured from etiology and cases due to autoimmune process), (b) **Type-II** ranges from predominant insulin resistance of a body to a more serious case of the predominant, secretory defect with insulin resistance, and (c) **Gestational** diabetes refers to glucose intolerance with onset or first recognition of pregnancy. Other types [13] are a variety of relative uncommon conditions and specific-gene-type, some of which are associated with other diseases or drug use. Its diagnostic criteria are based on glucose threshold, is as measured from its etiologic classification so that differentiating ***type-1*** from ***type-2*** is critical due to management. This is quite a difficult task in some cases [14]. Studies reveal that signs such as insulin resistance and the use of autoimmune markers antibodies (anti-glutamic acid decarboxylase, or anti-islet cell antibody) can help in its early diagnosis [9-11, 15] – though, these have not been adequately studied as diagnostic tests. Low C-peptide levels measured after months of clinical stabilization favors ***type-I*** (but not for acute hyperglycemia). Ultimately, clinical judgment and follow-up has always been a prudent method to treat and manage the disorder [13-15].

The complex nature of diabetes, its complications along with its varied types – often makes early diagnosis critical so as to help with drug-use administering and aid faster treatment. This has made manual diagnostic somewhat redundant, difficult, often inconclusive and time-wasting [refer to studies in 3-15]. Early prediction of diabetes thus, is a complex task due to the chaotic nature of its classification [16-17]. Studies continue to advance early and accurate detection of diabetes – even though, it is a challenging task [18]. Predictions are only an improvised means via which a model allows propagation of a set of observed dataset as the user seeks feats of interest. The dataset often contains ambiguities, noise and assumptions as inputted, so that the model yields an output of outcomes simulated via optimization methods and taxonomy [19-20]. We thus explore a deep learning reinforcement model to enhance accurate classification aimed at optimal solution of the task, chosen from a set of possible solution space – to yield output guaranteed of high quality and void of ambiguities. Models are tuned to be robust so they can perform quantitative processing to ensure as its new language, a qualitative knowledge and experience [21-24].

B. Study Motivation and Objective

Our study is motivated as thus [6-8]:

1. Many studies had previously aimed at production of a single heuristic to globally classify various diabetes-types. Our proposed model employs rule-based linguistic universe discourse to generate over 82-rules that are trained via the memetic deep learning neural network as in Section II.
2. Neural network models have often been known to employ hill climbing methods that often gets their solution trapped at local minima because their speed shrinks as such models often approaches its optima. However, this is curbed with the use of deep learning methods as in Section II with results as in Section III. Deep learning allows faster convergence of dataset classification – even though model as a decision support is a hybrid of genetic algorithm. This, allows better rule optimization, greater flexibility and adaptation of the rules as well as improved navigation of the model.
3. It has been noted that many stochastic models are rippled with (false-positive and true-negative) errors in diagnostic results. These may have been generated due to drug use and in some instance, symptoms of related disorders that mimics symptoms of the various diabetes-classes. To reduce such errors in classification (as in Section II/III), we employ a modular design that improves network intelligence, learning time of the network and its computational efficiency.
4. With hybrids (for this reinforced model), there issue of resolving conflicts in structured learning and from statistical dependencies imposed by data encoding as data signals are transmitted within the model is achieved via modularization that allows for greater efficiency as in Section II – though quite a tedious feat.

Thus, the goal of the study is to model selected data features of interest using a deep modular network design that simulates the generation of rules that will effectively classify data as well as reduce errors in result classifications.

2. Materials and Methods

A. Data Gathering / Sampling

We extend the study [2] via frameworks modelled in [25-27], we use dataset as presented in table 1 – obtained via a survey of questionnaires, consisting of two phases: (a) demographic data, and (b) tele-medical data. A total of a hundred questionnaires were distributed to various medical (diabetic) professional across forty teaching hospitals in six (6) Geo-political zones in Nigeria. Even with the insurgency, the sixth geo-political zone (North-North) gave a fair representation of the dataset retrieved. To generate the rule-based, selected dataset feats were tuned utilizing the proposed equation:

$$PFCMUDE = \sum(A, B, C, D, E) * X \quad (1)$$

A,B,C,D,E = picked questions option; X(0.02) = assigned questions option fuzzy range value, and X(0.00) = unpicked option.

Table 1. Rule-based Dataset Encoded For each class of Diabetes Dataset Values

Code	Fuzzy Set Linguistic Variable	Membership Function Degree		
		Type-1	Type-2	Gestational
P01	Frequent Urination	0.50	0.00	0.00
P02	Unusual Thirst	0.50	0.00	0.50
P03	Extreme Hunger	0.50	0.00	0.00
P04	Unusual Weight Loss	0.50	0.50	0.00
P05	Extreme Fatigue	0.50	0.00	0.50
P06	Serious Irritation	0.00	0.00	0.50
P07	Frequent Infection	0.00	0.00	0.50
P08	Blurred Vision	0.00	0.50	0.00
P09	Slow Healing of bruises/cuts	0.00	0.50	0.00
P10	Tingle/numb hands/feet	0.00	0.50	0.00
P11	Skin/bladder infection	0.00	0.50	0.50
P12	Nausea/vomiting	0.00	0.00	0.50
P13	Haemoglobin test > 10	0.20	0.20	0.20
P14	Leg cramp	0.20	0.20	0.20

(Source: Ojugo et al. 2015)

B. Hybrid Reinforcement Learning Ensemble

The Modular Neural Network (MNN) as detailed in [25-27] is an improved deep learning neural network with learning that features an independent series of intermediary components and module operating under a certain architecture. It advances a model that receives individual network module output as input that helps compute final output, resolved via tangent activation function. The large network is divided into potentially, smaller and more manageable network [25] with enhanced efficiency via connected units that exponentially increases, as independent networks are added. This complicates the network structure; But, also improves its computational efficiency, reduces time convergence on individual task assigned to segmented modules, and allows tasks to be executed in parallel with module that are re-organized to improve flexibility and adaptability [26].

The network enhances intelligence and increases time efficiency by reducing the network's learning time – achieved via an independent training algorithms applied at each module with training dataset implemented independently and more quickly. This makes the model more flexible, adaptable and robust as rules can be re-used independently at various networks. Re-usability of rules has been a tedious experienced with such large and complex networks. But, with appropriate data encoding and carefully selected feats – network experiences improved performance, improves flexibility of compartmentalization via removal of partitions of the interfaces and eliminates redundancy [27].

The MNN architecture is a larger network, comprising of smaller network. Its modularization allows for easy learning and understandability of the underlying feats of interest, grants model greater flexibility via task execution parallelism via compartmentalization, flexibility, eases code reuse and adaptability [28]. MNN passes data input via task decomposition and training modules via a multi-objective, multi-agent and multi-region support module that aids effective classification. MNN can be implemented using the multilayered perceptron, adaptive resonance theory and self-organizing maps. The network is trained via either the supervised, unsupervised or reinforcement learning [29].

For the study, our hybrid framework is divided into three (3) components: (a) a supervised cultural genetic algorithm, (b) an unsupervised Kohenen network, and (c) a knowledgebase – as in figure 1, as explained in the section below for the supervised genetic algorithm and the Kohonen self-organizing map neural network.

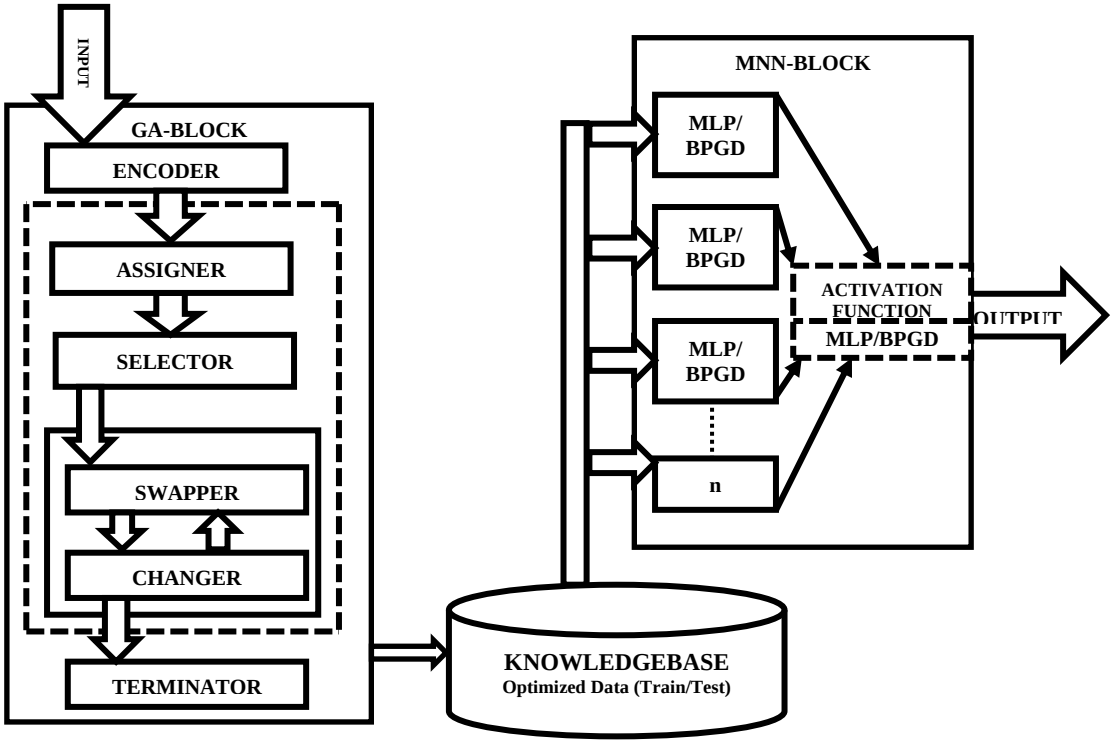

Fig. 1. Schematics Diagram of Genetic Algorithm Trained Modular Neural Network

- ✓ Supervised Cultural Genetic Algorithm (CGA): GA model is inspired by Darwinian evolution of survival of fittest, it consists of a chosen population with potential solutions to specific task. Each potential optimal solution is found via four operators [36] and individuals with genes close to its optimal, are said to be fit. Fitness function determines how close an individual is to optimal solution. Basic operators of GA includes initialize, fitness function and select, crossover and mutation [28-30]. Cultural GA as a variant, has some belief spaces defined thus: (a) ***normative*** belief (has specific value ranges to which an individual is bound), (b) ***domain*** belief (has data about task domain), (c) ***temporal*** belief (has data about events' space is available), and (d) ***spatial*** belief (has topographical data). In addition, an influence function mediates between belief space and the pool – to ensure and alter individuals in the pool to conform to belief space. CGA is chosen to yield a pool that does not violate its belief space and helps reduce number of possible individuals GA generates till an optimum is found [31-33].
- ✓ Kohonen Self-Organizing Map Neural Network is a feed-forward 2-layer network – arranged like in a grid. The first layer receives the initial input and transmits it unbound to second layer, which then provides competitive computation via the activation of its transfer function. Also, similarities among patterns are mapped into relations on the competitive layer. After training, the pattern relations are observed from this layer which are used as the result determination [26-27].

However, to achieve deep learning – we adapt the selected parameters and carefully constructing our Kohonen multi-layer network using a deep architecture at its input, hidden and output layers. We employ a hidden layer that transforms non-linearly from a previous layer to the next. We adopt the deep neural network approach in [34], which is trained via two phases: (a) pre-trained, and (b) fine-tuned processes.

The Auto-Encoder is an unsupervised multi-layered neural network consisting both an encoder and a decoder network. Its encoder seeks to transform inputs data-points from a high unto a low-dimension via an encoding function f_{encoder} as in Eq. 2 – where x^m is a data point, and h^m is the encoding vector obtained. Conversely, its decoder network seeks to reconstruct the function using f_{decoder} as in Eq. 3 with x^m as decoding vector from h^m. Thus, reverts the operations of the encoder. Ojugo and Eboka [34] in Gilrot and Bengio [35] details specific algorithms for encoding as well as decoding functions respectively as in Eq. 2 and Eq. 3 respectively.

$$h^m = f_{encoder}(X^m) \tag{2}$$

$$X^m = f_{decoder}(h^m) \tag{3}$$

At pre-training phase, *N* autoencoders can be stacked on to an N-hidden-layer so that with input accepted, the input layer and first hidden layer acts an encoders of the first auto-encoder. They are trained to minimize reconstruction error. Training parameter(s) of the encoder are used to initialize first hidden layer before proceeding to second hidden layer. There, the first and second hidden layers are selected as encoder(s) and as in earlier stage, the second hidden layer is

initialized by the second trained auto-encoder. This process continues till *N*th auto-encoder is trained to initialize final hidden layer. With all hidden layers stacked in the auto-encoder at each training *N*-times, they are thus regarded as pre-trained. This feat is significantly better than random initialization. It also achieves better generalization [34-39].

Fine-tuning is a supervised phase to enhance deep learning by retraining the optimized data labels. It computes errors as using back-propagated stochastic gradient descent (SGD), which randomly selects data, and iteratively update gradient direction with the weight parameters. It converges faster and does not require the entire dataset to simulate tractability – making it suitable for such complex structure. Eq. 4 yields E as a loss function, *y* is label and *t* is output for the proposed deep learning network [34, 36-38]:

$$E = \frac{1}{2}\sum_{j=1} M\,(y_i - t_i)^2 \tag{4}$$

The gradient of the weight *w* is obtained as a derivative of the error equation – so that an updated SGD is given by Eq. 5 with ŋ is step-size, *h* is number of hidden layers [29, 47]:

$$W_{ij}^{new} = W_{ij}^{old} - \eta .\left(y_j - t_j\right).y_j\left(1 - y_i\right).h_i \tag{5}$$

C. Experimental Proposed GAMNN Model

The experimental model is trained as thus:

a. Input is received via GA-block (basic operators such as encoder, selector, swapper, changer, and CGA terminator is used to train dataset. On completion, trained (optimized) dataset feats are held within knowledge base [28].
b. The MNN receives optimal dataset from knowledgebase with successive labeled/unlabeled rules perceived learnt instances [25-27]. The optimized-rules are propagated as IF-THEN rules (enhanced data with predefined variables) classified into various diabetes classes. Rules are modeled as a production system with four components: (i) ***rule set*** contains in each rule how to apply rule(s), and task(s) to be performed, (b) ***knowledgebase*** of optimized selected data stored as IF-THEN rules (diabetes) classes, (c) a ***control*** strategy to specify the order in which rules are compared to those in the knowledgebase to find a match and it seeks also a way to resolve conflicts that arise when several rules are matched at the same time, and (d) a rule ***applier***. Also, the MNN provides a self-learning capability and acts as the principal component analyzer with rules optimized by CGA's recombination and mutation operators so that the trained model or network can effectively, autonomously classify transaction into both class types.
c. Last stage of the network acts as a decision support and recognition system, with predicted values (output) and the automatic update of rules-knowledgebase, as transactions are diagnoses on encounter of new data, and consequently classified into class-types.

3. Result Findings and Discussion

A. Parametric Estimation, Tuning and Findings

Dataset is divided into 60:40 ratio. 60% for training and 40% for testing. The prowess cum predictive capability of the model is identified via data labels amongst the rule-based optimized dataset. Our deep learning Kohonen map uses 14-neurons at its input layer (a neuron for each feat). We also use 3-neurons for output layer (a neuron for each possible class of type-I, type-II and gestational). Other parameters are: (a) number of epochs, (b) activation function, (c) learning rate and (d) hidden layer topology. We used the Rectified Linear Unit (ReLU) Activation Function with 500-epochs. Optimal values were reached at 100, 300 and 500 epochs taking into account accuracy and training time. We seek minimum training error that will result in best fit, selecting the number of hidden layers was done via a trail-and-error method, and examining the results [25].

Figure 2 shows fitness score values for the generated rules. The rules generated that were fit was generally 82-transaction rules. These were partitioned into row values, each of which corresponds to an array of chromosomes for rules classified into diabetes classes.

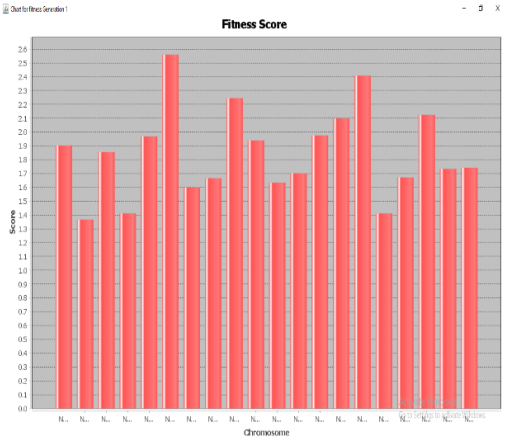

Fig.2. Fitness Score graph of the model

B. Discussion of Findings

The best possible number of layers was achieved by running tests on a single layer with 1 to 14-neurons at first instances – to yield greatest f-score with the least amount of training loss time. Addition of a second hidden layer of neurons from 1 to 17 yielded scores also; And, addition of a third hidden layer using the best possible number of neurons produced the greatest f-score. Thus, we selected the overall best possible hidden layer configuration. Results of first hidden layer with configuration of 14-neurons and f-score of 92% at 9th-iteration with a training loss of 1.140. F-score shows accuracy of each run – since we used an unbalanced dataset to train/test model with more records in normal class than in benign class [26-38].

Table 2. First hidden layer configuration analysis

Hidden Layer	Precision	Recall	F1-Score	Iteration	Training Loss	Epoch
1	0.84	0.92	0.88	44	0.294	500
2	0.84	0.92	0.87	24	0.278	500
3	0.84	0.92	0.88	26	0.293	500
4	0.84	0.92	0.88	9	0.501	500
5	0.89	0.55	0.64	19	1.496	500
6	0.94	0.94	0.92	18	1.400	500
7	0.86	0.53	0.63	4	2.230	500
8	0.90	0.84	0.86	16	2.071	500
9	0.92	0.93	0.92	18	1.140	500
10	0.92	0.92	0.90	16	1.779	500
11	0.88	0.91	0.89	7	2.134	500
12	0.91	0.92	0.89	8	2.320	500
13	0.87	0.87	0.87	13	2.006	500
14	0.92	0.92	0.90	8	1.970	500

Table 3 shows first layer with 14-neurons and others neurons varying from 1 to 17. Extra neurons cater for extra processing for optimal. Hidden layers of 9 and 11 neurons yielded f-score of 93% and training loss of 0.39. The second hidden layer is favored as it yields greater f-score.

Table 3. Second hidden layer configuration analysis

Layer	Precision	Recall	F1	Iteration	Train-Loss	Epoch
9, 1	0.84	0.92	0.88	25	0.293	500
9, 2	0.84	0.92	0.88	29	0.292	500
9, 3	0.91	0.92	0.91	15	0.583	500
9, 4	0.87	0.87	0.87	5	1.058	500
9, 5	0.92	0.92	0.90	13	1.628	500
9, 6	0.91	0.92	0.89	10	1.996	500
9, 7	0.84	0.92	0.88	24	0.281	500
9, 8	0.93	0.93	0.92	11	1.884	500
9, 9	0.92	0.92	0.89	12	1.590	500
9, 10	0.90	0.92	0.90	12	1.731	500
9, 11	0.95	0.94	0.93	14	0.390	500
9, 12	0.93	0.93	0.91	12	1.130	500
9, 13	0.91	0.92	0.91	20	1.929	500
9, 14	0.92	0.93	0.90	13	2.237	500
9, 15	0.94	0.94	0.92	7	1.765	500
9, 16	0.85	0.52	0.62	7	2.010	500
9, 17	0.94	0.94	0.94	6	1.620	500

Table 4 shows third configuration with first and second layer having 9 and 11 nodes and varying third hidden layer. Best configuration is 9-11-14 neurons, yielding f-score of 92% with a training loss at 0.560.

Table 4. Third hidden layer configuration analysis

Layer	Precision	Recall	F1	Iteration	Train-Loss	Epoch
9, 11,1	0.83	0.91	0.87	32	0.287	500
9, 11,2	0.91	0.92	0.89	6	1.592	500
9, 11, 3	0.83	0.91	0.87	29	0.280	500
9, 11, 4	0.90	0.91	0.90	16	1.564	500
9, 11, 5	0.92	0.92	0.90	18	0.741	500
9, 11, 6	0.93	0.92	0.89	21	0.282	500
9, 11, 7	0.92	0.93	0.90	6	1.322	500
9, 11, 8	0.90	0.86	0.88	6	1.239	500
9, 11, 9	0.90	0.91	0.90	7	1.886	500
9, 11, 10	0.88	0.91	0.89	8	0.623	500
9, 11, 11	0.92	0.93	0.91	5	2.000	500
9, 11, 12	0.86	0.83	0.85	11	2.370	500
9, 11, 13	0.86	0.83	0.84	8	2.350	500
9, 11, 14	0.93	0.92	0.92	15	0.560	500
9, 11, 15	0.93	0.93	0.91	8	1.204	500
9, 11, 16	0.94	0.94	0.92	8	1.730	500
9, 11, 17	0.87	0.54	0.63	12	1.730	500
9, 11, 18	0.93	0.94	0.93	6	1.850	500
9, 11, 19	0.93	0.93	0.90	9	0.660	500
9, 11, 20	0.92	0.92	0.90	28	1.180	500

C. Model Performance Evaluation

From our confusion matrix, (a) sensitivity measures how likely a model will predict the presence of all classes of diabetes symptoms when it is present, (b) specificity measures how likely model will detect the absence of diabetes symptoms when it is not present, and (c) accuracy measures the proportion of the true results seen as the degree of truth of a prediction. Thus, we compute the sensitivity, error rate and accuracy to evaluate model performance as in Eq. 6 to Eq. 8 – given that the values TP = 53, TN = 7, FP = 1 and lastly, FN = 1. Thus, we have:

$$Sensitivity = \frac{TP}{TP+FN} = \frac{53}{53+1} * 100 = 98.1\% \quad (6)$$

$$Specificity = \frac{TN}{TN+FP} = \frac{7}{7+1} * 100 = 87.5\% \quad (7)$$

$$Accuracy = \frac{TP+TN}{TP+TN+FP+FN} = \frac{53+7}{53+7+1+1} = 95\% \quad (8)$$

The model is found to have a sensitivity of 98%, specificity value of 87.5% and prediction accuracy of 95% (0.95) for data inclusion that were not originally used to train the mode. This is in agreement with [26-27, 30-31].

4. Summary and Conclusion

After testing the model, the results were also compared to other benchmark model as thus: (a) GA took 43seconds to find the solution after 98-iterations (at best). Recall that for deep learning, we observed earlier that our best forecast and optimal values were reached at 100, 300 and 500 epochs. CGA was run 25 times (to eradicate non-biasness), and it found optima each time – though, convergence time varied between 0.89econds and 56seconds. We later observed that the model convergence time depended on how close the initial population is to the solution as well as on the mutation applied to the individuals in the pool. The use of the rule-based solution was adopted using fuzzy variable dataset (as preprocessor). Our MNN architecture is a larger network, comprising of smaller network. Its modularization allows for easy learning and understandability of the underlying feats of interest, grants model greater flexibility via parallel task execution and compartmentalization, greater adaptability and eases code reuse. MNN passes input via task decomposition and training modules via a multi-objective, multi-agent and multi-region support module that aids effective classification.

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Authors' Profiles

Arnold Adimabua Ojugo received his BSc in 2000, MSc in 2005 and PhD in 2013 – all in Computer Science from The Imo State University Owerri, The Nnamdi Azikiwe University Awka, and The Ebonyi State University Abakiliki respectively. He is an Associate Professor currently at Department of Computer Science (Federal University of Petroleum Resources Effurun) in Delta State, Nigeria. His research interests are in: Intelligent Systems, Machine-Learning, Performance and Ubiquitous Computing, Data Security and Graph Theory. He is also an Editor with the Progress for Intelligent Computation and Application, SciencePG Journals, and others. He is also a member of: Nigerian Computer Society, Computer Professionals of Nigeria and International Association of Engineers (IAENG).

Elohor Ekurume, in 2009, received her BSc in Computer Science from Benson Idahosa University, Benin-City in Edo State, and her MSc in Information Technology from the University of Bradford, Bradford, United Kingdom in 2013. She currently lectures with the Department of Computer Science at the Delta State University Abraka in Delta State, Nigeria. Her research interests are in: Intelligent Systems, Data Mining, Machine-Learning, and Ubiquitous Computing. She is a member of: Computer Professionals of Nigeria.

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Editorial Assistant

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Digit Sports Research
New Technology in Teaching Domain Application
Classroom Instruction Research
Management Science Teaching Research
Lifelong Education Research
E-service
Artificial Intelligent System
Control Technology
Production and operation management
Quality control and reliability
Logistics and supply chain management
Application of Systems engineering and Operational research
The safety management
Management of technology, innovation and evaluation
Financial engineering and risk management
Digital library management and technology
Knowledge acquisition, expert systems
Knowledge based systems to support database design
Knowledge management
Management Information Systems
Network culture and harmonious society
Object-oriented enterprise modeling
Organizational management
Project Management
Public Policy Management
Software copyright infringements
Systems analysis and design methods
Information economics
Information Quality and Strategy
Information resource management
Information systems planning and management
Information Technology and sustainable development of corporation
Information Technology Management
Economics of Information and System Security
Massive Storage and Data Management
Metadata Processing and Management
Organizational Issues of Information
Software Agent based Systems in Logistic

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