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Intelligent Healthcare on Hydrocephalus Management using Artificial Neural Network Algorithm

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Abstract: ***Shunt efficiency plays an important role in hydrocephalus management. Artificial intelligence has been used far and wide in managing healthcare treatment such example is the use of artificial neural network for increasing shunt device efficiency as through the research done has find that there are gap in current practice. This research focus in improving artificial neural network algorithm to create a more efficient hydrocephalus shunt device that could detect any shunt malfunctions before used clinically on patient. The improved algorithm would also help to ensure a more efficient shunt management, in terms of after shunt insertion; predicting shunt infection to decrease the length of hospitals stays and mortality rate for patients especially for children. The method proposed is by improving the current algorithm that are currently being used by the shunt device to increase its efficiency and also enable advance data collection for more accurate prediction.***

Keywords: ***Artificial Neural Network Algorithm, Hydrocephalus in children, Shunt-device efficiency.***

I. INTRODUCTION

Intelligent healthcare is focused in making sure that patient monitoring and treatment is given full attention. Many solution can go beyond to ensure active intervention and treatment on sensory management and have patient feedback, thus taking healthcare out of hospital environment [1]. Artificial intelligence (AI) helps in making use of healthcare data and analysis technique into something that is easier to be monitored and managed by using various AI technique. AI uses algorithm that are then have self-correcting abilities that would help improve accuracy in processing medical data [2]. This would help to decrease fatality rate that resulted from wrong prediction or processing of data especially made from human error. The human brain is surrounded by a fluid called cerebrospinal fluid (CSF), that protect it from physical injury, keeps the tissue moist and transport the product of metabolism. If the rate of CSF absorption or drainage is consistently less than the rate of production, the ventricles expand causing the brain to become compressed, leading to the disorder known as hydrocephalus. This lead to elevation of pressure exerted by cranium on brain tissue, cerebrospinal fluid, and brain circulating blood volume known as intracranial pressure (ICP), and manifest as symptoms such as headache, vomiting, nausea or coma. Is left untreated, elevated ICP may lead to serious problems in the brain. Chronic hydrocephalus especially in children usually resulted to skull enlargement, spasticity, neurological deficit in children and also dementia [3].

Pediatrics hydrocephalus is critical especially in lower income countries as patients could not get the required treatment needed as there are limited access to get sufficient neurosurgical care [4]. Since 1960s, the usual treatment for hydrocephalus is to insert a shunting device in patient CSF system [5]. This is simply a mechanical device that that would divert accumulated CSF around the obstructed pathway and return it into bloodstream, thus reduce CSF and alleviate symptoms of hydrocephalus. Despite shunting developments, shunting can have complication, and different shunt are associate to different type of complication. Shunt complication could be dangerous and fatal if are not discovered early and are not treated. However, shunt malfunction and complication are generally not detected before they are used clinically on patients [6].Furthermore, other than detecting shunt malfunctions before or when used on patients, it is also important to ensure that the shunt device is efficient in managing symptoms. Shunt device efficiency are measured on its effectiveness in collecting and regulating the CSF fluid level to ensure that the fluid regulation are at its best level as higher or lower CSF level would lead to complications in patients, and if not treated or managed earlier could contribute to patient fatality[6]. Some of shunt advancement is focused on self-monitoring technology whereby the shunt is programmed with artificial intelligence advancement that would do its own monitoring and controlled by reading the data that have been collected by the device itself and stored in memory. The shunt itself would decide if there is any irregularities in ICP readings and would give out signals or warning to patient, caretaker or doctors regarding the patient health [7] The aim of this research is to find solutions to increase accuracy in monitoring hydrocephalus thus decrease mortality rate in patient suffers from hydrocephalus caused by shunt malfunction. Algorithm from artificial neural network will be manifest with the best advancement in current technologies used to manage hydrocephalus to help patients manage their own conditions and doctors to make decision through the collected data to direct the best treatment options for the patients.

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A. Problem Statement

There is a high number of complication rates for failures of shunt device which are only detected after used clinically on patient [8]. There is a need in advancement of shunting device algorithm for early detection and for better shunt device management. There is an urgency in better algorithm to improve shunt device efficiency that would be used to help doctors manage the patient health through the collected data, which helps to find suitable treatment and reduce lengthy hospital stays.

B. Research Question

- What latest shunting technologies are used in monitoring and treating hydrocephalus?
- How to ensure the shunt device could efficiently collect data for detecting shunt malfunction?
- What algorithm is used that can increase shunt efficiency?

C. Research Objectives

- To design a solution in terms of shunt algorithm that would help detect shunt malfunction before used clinically on patient.
- To study the management of shunt device used on individual that is successful and adaptive to the treatment of individuals. If any malfunction on the level of ICP, the system would be able to detect and alert to update any valve schedule to lower the urgency of situation.
- To improve on algorithm that would increase shunt efficiency as to help in monitoring patient symptoms criticality and complications.

D. Scope

This research focus in finding and improving the algorithm that are used for the shunt device to increase its efficiency and ensure a better shunt management. There is a gap in past works in improving artificial neural network algorithm for hydrocephalus shunt management [9].

A solution could be develop after combining an efficient algorithm and effective management of shunt device to ensure that the criticality and complication of the patient condition assessed correctly by the device and that preventive measure could be taken accurately.

II. LITERATURE REVIEW

A. Hydrocephalus in Children

Human brain is surrounded by fluid called cerebrospinal fluid (CSF) which would act as a barrier that will protect the brain from any physical injuries, controls intracranial pressure (ICP) and carries any product resulted in metabolism [10]. Hydrocephalus is a disease that basically resulted in problem in balancing CSF within the brain and if left untreated would resulted in serious impairment to the patient and would be fatal. In normal cases, the CSF would be automatically produced and absorbed by natural drainage system that is provided by the brain that would regurgitate a constant amount by itself. But for hydrocephalus patients, they would need an outside intervention in the form of a mechanical shunt to help them control the CSF.

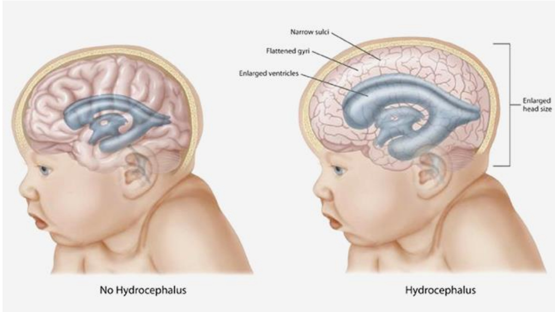

Figure 1 Difference between Hydrocephalus patient brain and non-hydrocephalus patient retrieve from http://www.nj.gov/health/fhs/sch/documents/facts_ccns.pdf [11] on March 13, 2019

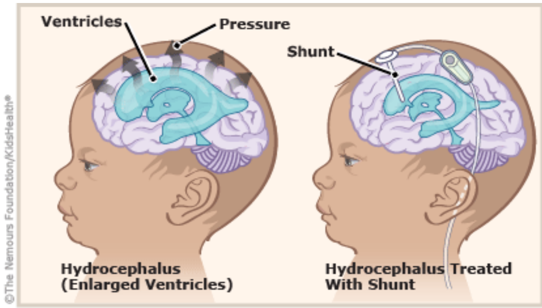

Figure 2 Hydrocephalus patient treated using a mechanical shunt retrieve from https://nortonchildrens.com/health-library/article/?url=/en/parents/hydrocephalus.html on March 13, 2019

1) Types of hydrocephalus

There are a few process of hydrocephalus which require different handling procedure. Two commonly treated hydrocephalus processes are communicating hydrocephalus and obstructive hydrocephalus [12] [13]. Other unique processes are benign external hydrocephalus and arrested hydrocephalus [13]. The processes will be explained in Table 1.

Table 1 Types of Hydrocephalus

Hydrocephalus Process	Explanation
Communicating Hydrocephalus	If there is any failure in absorbing CSF, or any venous drainage insufficiency or overproduction of CSF. Happens when there is full communication between ventricle and subarachnoid spaces.
Obstructive Hydrocephalus/ Non-Communicating Hydrocephalus	Happens when there is an anatomy disruption to circulation of CSF within ventricle. Most commonly represented by obstructive and is caused by intraventricular or extra ventricular lesion that disrupt the ventricular anatomy.

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Benign External Hydrocephalus	A deficiency of absorbtion in infant and early childhood with raised intracranial pressure (ICP) and enlarged subarachnoid spaces. Ventricles are usually not increased in size significantly and are given treatment and solution within 1 year.
Arrested Hydrocephalus	An incomplete obstruction or lack of absorption of CSF. Failure that usually happens especially after minor head injury.

2) Causes of hydrocephalus in children

Hydrocephalus in children comes from 2 different causes that is from congenital causes or acquired causes [12] which will be shown in table 2.

Table 2 Causes of Hydrocephalus

Congenital Causes of hydrocephalus in childhood	• **Genetic conditions:** X-linked Aqueductal stenosis • **Brain malformations**: myelomeningocele, Dandy-Walker malformation, neuronal migration defects; vascular malformations • Prenatal infection • Prenatal hemorrhage
Acquired Causes in infancy and childhood	• Late manifestation of congenital causes • Intraventricular hemorrhage in preterm infants • **Vascular lesions:** vein of Galen malformation • **Infection:** meningitis • Brain tumors • Head injury • Idiopathic (unknown cause)

3) Treatment for children with hydrocephalus

Treatment options for children especially with indicative symptoms [14], the treatment include surgical implantation of shunting device to divert the CSF out of ventricular system in the brain. A shunt is a device that is made up of a narrow tube to drains and regurgitate CSF fluid that has built up inside the brain to another part of the body. Shunt are named to where they are located in the brain and where they are diverting the excess CSF. If the shunt are diverted into peritoneal cavity, the name of the shunt would be ventriculoperitoneal (VP) shunting. The VP shunt drains CSF into the abdomen. While for ventriculopleural shunt dries the excess fluid into spaces surrounding the lungs and for ventriculoatrial (VA) shunt drains into the atria of the heart. Usually children with VP shunt are with the most number of complications that would require emergency treatment [13].

Furthermore, repeated shunt complication that may arises also are taken into consideration as it could lead to impaired cognitive development, visual impairment, repeated surgery, long term disability and could lead to fatal. Thus, there are many research done to help minimize impact or prevent the complication that would arises especially from shunt failure. Shunt devices are popular for high failure rates, difficulty of diagnosing failure and limited control option [15].

B. Current trends in managing Hydrocephalus (Concept)

According to Ellenbogen & Mallucci (2018), hydrocephalus management was revolutionized since 1950s starting with the invention of CSF shunt, as in the past usually people suffering from hydrocephalus only resulted in death. As of current trends, the uses of ventriculoperitoneal (VP) shunt is one of the common procedure done in combating hydrocephalus problem. Although the damage done CSF diversion is minimal, more precautious step should be done to lessened injury and maximize outcome from the patient itself.

1) Smart Shunt-based device

The concept of a smart shunt is made up from implantable system that are covered by hardware and algorithm to control the buildup of CSF and its drainage system based on input or feedback gathered by some condition. Most of the smart shunt has same framework and are built on same set of component such as sensor, a fluid control mechanism represented by valve, an actuator to control the movement of the valve, housing to differs between electric component and its body, power source and communications which is an important aspect as to ensure monitoring and management of hydrocephalus are successful [15]. The framework that covered all the above aspect has many variations done by different research group.

As said by Lutz et al., (2013) smart shunt is a shunting device that are able to monitor and measure ICP or CSF drainage rate and also at the same time levitate the CSF drainage of the shunt based on the collected information. Rather than traditional mechanical valve, the control algorithm for smart shunt could overcome many inadequacy of mechanical valve and would allow application of theories to improve CSF management. As smart shunt depended on sensor productivity, the sensor-based control would have the capacity to query and input data for the device on patient response and shunt functionality and the data then could be shared to healthcare system to enable real-time sharing and at the same time personalized and accurate control to the patient. The smart shunt also ensure that there is minimal failure rate and the impact of failure rate decreased as the data collected would be able to predict the lifespan and condition of the shunt manifest in the patient. Thus, self-cleaning and also detection of shunt failure could be predicted before it happens.

Through a research done by [16], a mechatronic valve with control software is being experimented on which the control software will modify the time of the opening and closing of the implanted valve based on input gather on ICP or CSF readings.

Moreover they also highlighted that patient feedback is one of the many input that would be use to diagnose patient symptoms at any given time and would enable patient or caregiver to monitor and manage hydrocephalus and at the same time would give an advice and option of contacting directly the physician for further confirmation. The research would consist of an implantable subsystem and external subsystem. A wireless communication between external subsystem and a smartphone that is operated by the patient or caregiver will be design so that a real-time patient feedback system would be realized in ensuring a personalized management of hydrocephalus and also self-diagnosis of any shunt malfunction to minimize any damage.

One of the challenges of using implantable device in any medical based appliances is the maintainability especially to access, replace and modify the device if needed especially in long term wear by the patient [17]. The research done by Momani and Alkharabsheh has founded that an updating algorithm could be used to remotely modify the device and bidirectional management shunting method was used to reprogram the implantable device that would ensure an efficient hydrocephalus management. A dynamic mechanical shunt was used instead of passive mechanical shunt that would help patient to monitor their condition and lessen period of shunt revision for them. Other than that, the group manage to use a new technique that would help to manage software updates through RF transceiver. The collected ICP readings would be stored in a RAM and then an intelligent representation of data would be shown and are used for diagnosis purposes.

Next, a research and design done by [5] whereby the team focus on developing an implantable pressure sensor which would regurgitates the ICP readings. If the ICP too high, the valve will be opened to relieve the ICP, but when it is too low, the valve will be closed. The paper discuss on ways to controls the intracranial pressure (ICP) in which a sensor for long term ICP measurement will be developed so that malfunction could be detect early. Other than that, overshunting concerns has also been highlighted and the short term and long term effect of it has been ruled out in the paper. The team also focus on ventricular shunt which is famous for having a high failure rate of 50% of patient in two years, solutions such as adding shunt resistance using antisiphon devices would reduce the obstruction rates. The team then explained through the rest of the paper on a novel system composition made from ICP sensor, smart shunt valve overview, valve controller, mechanism and prototype, communication, external reader and display regarding the smart shunt system that has been design by their team. At the end of the paper, they explained that they have not done any testing on animal, but supposedly in vivo test of sheep could be used to test on some system functions effectively.

Another group of researcher develop a new approach that is through cognitive system over a distributed network of hydrocephalus patients with intelligent shunting system called e-Shunt to automate, improve treatment and also management of hydrocephalus [18]. The group specify that the methodology objective is to equip both patients and physicians with a tool for shunt monitoring and autonomous treatment process with the ability to communicate and a method to automate ICP analysis and classification with database of ICP recordings and treatment regime. This system would use data mining and knowledge acquisition technique for analysis purposed and give interpretation of data collected on hydrocephalus through a large network of interconnected hydrocephalus patients and physicians at the same time, ensuring a personalized and autonomous treatment with the patient environment.

2) Intelligent mobile application

Nowadays, most people would have atleast a smartphone within them for many purposes. Smartphone make it possible for a lot of integration to be done in creating something that helps human in managing their daily task. Other than that, people are becoming reliant and dependent fully to their phone for completing more of their daily activities. With the emergence of more technologically competent device, more enhancement and integration of hardware and software could be done, especially in the field of healthcare whereby many intelligent mobile application has been design and invented for research purposes and public use.

In this case, there are some groups of research done in the area of hydrocephalus intelligent mobile application to help patients, doctors and caregiver in managing the symptoms [19]. Studies shown that there are no intervention that are successful enough to rule out shunt malfunction, thus a group a researcher founded a way to make an implantable sensor that will measure ICP reading and ensure that from the data collected, shunt malfunction can be detect earlier [5]. The sensor then will work with microcontroller, shunt valve and monitored by an external controller using display or any smart phone used by physicians or caretaker. This enable daily ICP reading to be monitored and to do any preventive actions if there are any changes or abnormalities in ICP reading.

In addition, a team of researcher has invented Intelligent Neurodiary Application System (iNAS) [13] which aims to be a centralized information system that will store information regarding to hydrocephalus patients and enabled patients conditions to be remotely detain in the system and monitored, process by physicians without the need of frequent hospital visits. This application aim to provide central reference point of information that would allow monitoring of any complications while enabling patients and caretaker access to consultation when necessary and during emergency. The system (iNAS) is using modular approach that is three tier software architectural framework, cloud-based framework to host web front ends and the business logic. The infrastructure will enabled the backend to be manage to maintain the database, API and interface used by the system. Other than that, security issue could be handle better by using the framework. Furthermore, the (iNAS) interface screen is developed using JQuery mobile framework as they have many options to choose from in terms of widgets and tools supported by HTML5 technology A simple overview of the system three-tier architecture is shown as in figure 3.

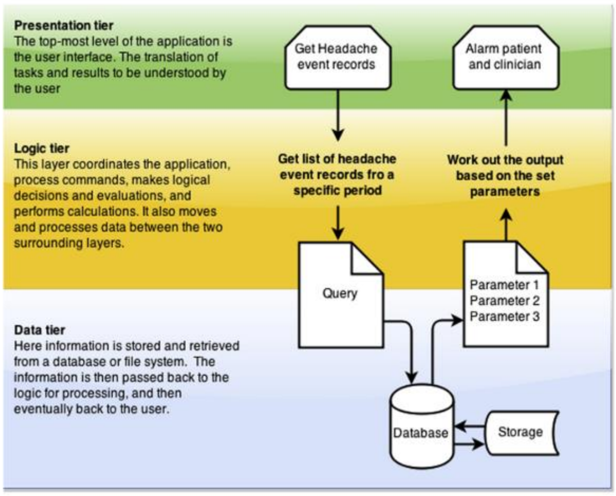

Figure 3 Simple overview of a three-tier application (Farrugia et al., 2016)

The testing that is done by the research through usability testing accomplished by clinicians, in this research, it is stated that, all pediatric neurologist and pediatric neurosurgeons working at Mater Dei general hospital in Malta participate in accessing the applications. Usability testing are important as it aims to achieve full operations of the system and user acceptability, other than identify other usability issues for further improvement before system is deployed [20]. Usability testing proved to be important as it ensure that eHealth applications are usable, effective and could be used in ensuring effective health care [21].

Other than that, research group which focused on designing intelligent and personalized shunting system for hydrocephalus has stated that they have found a way to design multi-agent system for it. The main backbone for the research would be by using patient feedback and ICP reading to ensure the maintaining CSF flows and weaning. The proposed system are said to overcome drawbacks and solved all the limitations and gaps of the current shunting procedure [10]. Like other intelligent shunting system, it comprises of both internal (implant) shunting system and external intelligent system which could be represent by patient smartphone, wireless transceiver or a microcontroller. The input of the system would be from the patient feedback, ICP readings, and clinician intervention. Then, the input will be store in database, and an agent which is Belief, Desire and Intention (BDI) architecture will be used, as with Prometheus methodology to develop the multi-agent system. 7 agent are developed such as decision maker, adjustment handler, weaning manager, external communicator agent, valve manager, sensor manager and internal communicator.

C. Artificial Neural Network

1) General concept of artificial neural network

Artificial neural network is a form of advancement in computing system that would need to use hundreds of single units act as a processor known as neurons or nodes that are connected to each other and operate in parallel forming a pattern to enable these neurons to communicate with each other. These neurons are interconnected through a connection link that would carries the information on the input signal. This is important as the information are used by the neurons to find solution to a particular problem as it would excite the signal that are passed through. Every node would have internal state called activation signal. As a result, output signal that would be sent to other units are produced as a result of combining input signals and activations rules. ANN complexity has a long way to go to match the capacity of human brain that have more than 100 billion neurons as of date rarely have more than a few hundred of processing neuron. However, ANN have proven themselves to be accurate in predicting data. The network are trained through its memory used experience as a guidance which are collected to detect patterns and data [24] [25] [26].

Figure below shows the general model of ANN [27]:

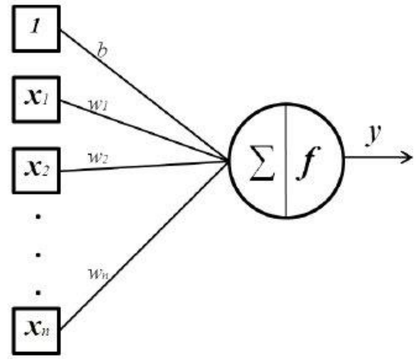

Figure 4 General model of ANN fetch from Elmissaoui et.al (2013)

Whereby *f* is the activation function,

$$y = f(\sum_{i=1}^{n} w_i x_i + b = f(z)$$

It is a simple two layer network consisting of hidden layer and output layer. Two neuron is located in input layer x_i and x_2 not including bias input. The arriving signals as an input, are multiplied by the connection weight are combined and then passed through a connection link resulted as an output for the specific neuron. The activation function is the memory holder for all the neurons input [27], [28].

Another model of an artificial neuron [28],

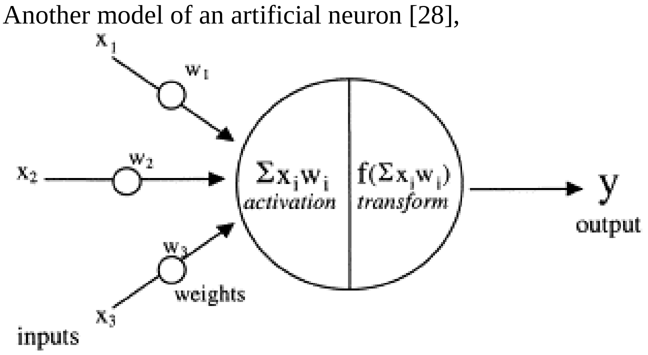

Figure 5 Model of artificial neuron from Beresford (2000)

The neurons competes with each other. Artificial neurons can receive either stimulative or deterrence factor.

A stimulative neurons would cause additional mechanism of the next neurons and deterrence input would cause a subtraction. Neuron also practicing lateral inhibition as it could restrain others neurons in same layer. They would compete in choosing the highest prospects and suppress all others [28].

There are two types of connection that depends on appearance of feedback connection in the network, one is feedforward architecture (figure 6) which does not have a memory stores of previous output or absence in connection from the output to the input and another; and another is feedback architecture (figure 7) that has memory of previous state so it would have additional memory acting as additional knowledge that could be used to increase the accuracy of the output.

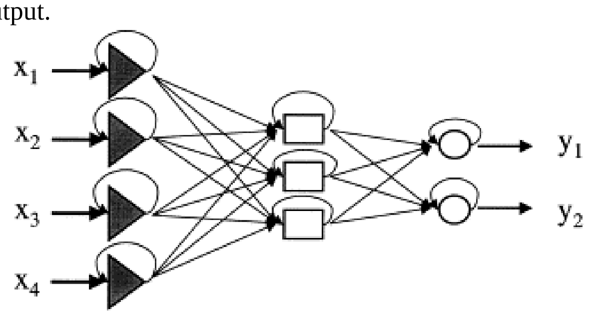

Figure 6 Feedforward Network

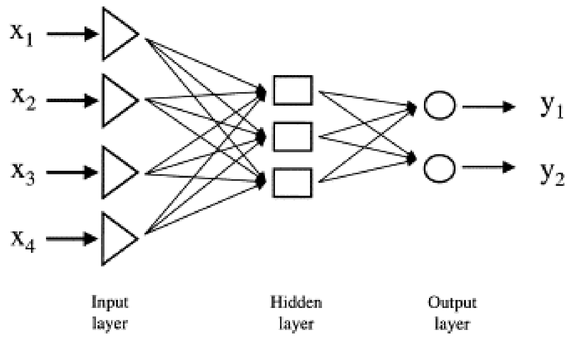

Figure 7 Feedback Network

Once a network has been structured, the network will be trained using either of supervised learning or unsupervised learning method. Supervised learning method use to predict target values from inputs. It relies on both input and output data of the training set. While for unsupervised learning, the learning is only provided with input. The system forms a decision on which features he need to use to form data through adaption. The neurons will work their way through competitive learning to get the most desirable output thus output is predicted.

2) The use of artificial neural network in Healthcare

With growing needs of industry 4.0 in healthcare sectors, artificial intelligence (AI) have played an important factors as it helps the healthcare to grows at a face pace in improving its efficiency and effectiveness of health management thus contributing in collecting data that are used to create something useful information to find new cures and technologies [29], [30]. Artificial Intelligence uses sophisticated algorithm to read information that are extract from healthcare data and from that created many opportunities such as advancement in cure or healthcare technology in terms of equipment, machine, management that would benefit the community. AI have played an important factor in helping physician making better clinical decision.

The availability of healthcare data makes it possible for the data to be useful in evolving healthcare management for clinical practice especially in making decision. Before the steps whereby information from healthcare data could be extracted, the AI systems and the algorithm need to be trained, so that they could recognize clinical activities [2]. Some of disease that used AI in increasing their efficiency in clinical practices are cancer, nervous system disease and cardiovascular disease.

Table 3 AI Uses

Disease	Explanation
Cancer	• Neural network technique is used to diagnose cancer whereby input are gain from genes (estimated by PC's) and the output are tumor categories[31] • To predict breast cancer whereby input are from mammogram images and output is tumor indicators[32]..
Nervous system disease (Neurology)	• In Parkinson disease where neural network are used using input from motor, non-motor symptoms and neuroimages[33]
Cardiovascular disease (Cardiology)	• Using cardiac images to diagnose heart disease [34]

Artificial neural network (ANN) has been used in predicting ventriculoperitoneal shunt infection in children. A model was developed to investigate the relationship between shunt infection and predictive factors. Intelligent models are developed to assess patient factors as well as surgery information, the result, ANN shows to have better performance but there is a limitation as ANN unable to process weight of single variables on output. Another limitation found is that absence and/or limited medical data, small sample size and assortment of clinical demonstration [35][9].

III. METHODOLOGY

In this chapter, various methods in collecting data to ensure the success of intelligent healthcare on hydrocephalus using deep neural network a reality. The research activity will be explained on section 3.1 while Gantt chart for this research timeline will be displayed in section 3.2.

A. Research Activities

- Preliminary Activities
  - Background Study and Literature Review
  - Define problem statement

- ○ Consultation with medical expert/practitioner on the hydrocephalus shunt device technologies used in Malaysia.
- ▪ Design artificial neural network algorithm for Hydrocephalus
  - ○ Study existing algorithm and shunt device advancement
  - ○ Improve existing algorithm
  - ○ Search for any gaps in implementation of algorithm
- ▪ Evaluate and Modify algorithm
  - ○ Testing algorithm using case study
  - ○ Analysis and discussion
- ▪ Documentation

1) Preliminary Activities

During this period, background study and literature review regarding Hydrocephalus concept and existing technologies, models of existing shunt device advancement are found and are translate into literature review. Research are done on existing works regarding intelligent hydrocephalus management focusing on the shunt device to find any gaps or limitation or existing improvement done relating to the topic of research which are then used to form problem statement. Related theory regarding hydrocephalus, its management and treatment, existing works on the technologies improvement that have been done and research on the algorithm are recorded in chapter 2, literature review. Furthermore, an interview has been done with doctor from Hospital Pantai Manjung, Manjung, Perak regarding the current technologies available to manage hydrocephalus has been done, and in the future, a collaboration with Hydrocephalus center in Hospital Kuala Lumpur will be done to do interview on the efficiency of current management of Hydrocephalus and the research that has been done to increase its efficiency by their research center and also an interview with a PHD student in RWTH Aachen, Germany would be done to find out the outcomes of his research on hydrocephalus management. All relevant data has been collected from the preliminary studies has been use as guidance to define and formulate the problem statement stated in Chapter 1.

2) Design of artificial neural network algorithm for Hydrocephalus

A model would be designed on the hydrocephalus intelligent management which would combine mobile application from smartphone, and the shunt device which has gone through an improvisation on its algorithm to increase the device efficiency through artificial neural network. The algorithm then would be tested if its increase any efficiency that would improvise shunt device and thus lead to better management of hydrocephalus and close any existing gaps that has been found.

3) Evaluate and Modify Algorithm

The algorithm from the shunt device which has been tested on its algorithm efficiency then would be modified as to increase its efficiency. The algorithm then would be tested if its increase any efficiency that would improvise the device. The device implemented with new algorithm then would be tested for results. To analyze the result, qualitative method and also statistical tools will be used to see the difference it makes in terms of improvement to the system. The results then would be evaluate.

4) Documentation

All documents related to the research would be collected, and documented throughout the research period.

B. Gantt chart

Gantt chart is important in any project or research as it helps in ensuring that the research is done timely and the data collected from the research activities are organized. Furthermore, it helps in ensuring the researcher to complete task within time framework and also keep track of the activities done or in queue and also dateline can be achieved. Gantt chart is shown in Table 4,

Table 4 Gantt chart

No	Detail/Month	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3	4	5	6	7	8	9	10	11	12
		First Semester						Second Semester						Third Semester						Fourth Semester					
1	Background study and Literature Review																								
2	Define and Formulate Problem ststement																								
3	Study existing algorithm and shunt device advancement																								
4	Improve existing artificial neural network algorithm for hydrocephalus shunt device																								
5	Evaluate and Modify Algorithm																								
6	Analysis and Discussion																								
7	Documentation																								

IV. RESULT AND DISCUSSION

A. Proposed solution

A newly improved artificial neural network algorithm will be design and tested for shunt device that would resulted in higher accuracy and efficiency in predicting shunt malfunction before and after it is used clinically on patients using case study.

V. CONCLUSION

Based on the research that has been done, there is a need for systematic research on theory regarding to Hydrocephalus management and also understanding on artificial neural network algorithm to help in achieving the aim of this research that is to ensure increasing efficiency in hydrocephalus management in shunt device. This research helps in design and improvise artificial neural network algorithm in shunt device in order to make the device more accurate in diagnosing and managing hydrocephalus thus helps doctors in ensuring the best treatment option for patients. As explained in literature review, related literatures on Hydrocephalus symptoms, treatments options, concept regarding trend in managing hydrocephalus, latest technological advancement in terms of shunt device, intelligent mobile applications regarding to hydrocephalus management and artificial neural network has been stated to support the research needs.

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