A STUDY OF THE EFFECTS OF DIABETES CONTROL WITH INSULIN USING AN ARTIFICIAL NEUROMOLECULAR SYSTEM

Abstract:
Diabetes has been recognized a vital death cause in this century. However, diabetes control has not been very successful. This is because for a patient with diabetes, in addition to his/her physiological status, there are many factors that might affect the effectiveness of each individual treatment. Therefore, there is a great deal of difficulty in establishing a guideline to decide the appropriate dosage for a particular patient. In this paper a study on diabetes control with insulin using an artificial neuromolecular system (ANM) is introduced. Our data were collected from one of major hospitals in Taiwan. The data set was comprised of 191 records, which were partitioned into a training data set and a test data set. Our experimental results showed that the ANM system can effectively predict the occurrence of problems related to insulin dosage of bioartificial pancreas, with a satisfactory accuracy.
Keywords: artificial neural network, evolutionary learning, data mining

1. INTRODUCTION

Diabetes has been one of the most important global public health issues in the 21th century. Among all chronic diseases except for hypertension, the prevalence rate of diabetes is the highest (4.3%). Based on the 2005 statistics of Department of Health, Executive Yuan, diabetes, as the 4th leading death cause in Taiwan, has the highest increasing rate among the 10 leading death causes (mortality related to diabetes for every 100,000 was 7.91 in 1980, 34.67 in 1997, and 42.5 in 2006). The etiology of diabetes is closely related to the function of pancreas, which secrets insulin to regulate blood sugar levels in the human body. If the insulin secretion function of pancreas is compromised, blood sugar levels will be imbalanced and risen to cause so call diabetes. Diabetes has two types. Type 1 diabetes is related to insufficient production of insulin by pancreas while type 2 diabetes, despite of normal insulin production, is caused by the resistance of cells to the action of insulin, leading to that glucose could not get into cells effectively and therefore, blood sugar levels rise. Normally, with an excellent control of blood sugar levels, diabetic patients still could live a normal life with a morbidity being reduced for at least 50%. However, most diabetic patients were not able to adequately control their blood sugar levels, which could be due to several reasons. First of all, insufficient health education may make patient unaware the serious consequences of diabetes. The second reason is the difficulty in the overall control and adjustment of diet, exercise, and medication. Thirdly, although various medications are indicated for diabetes, there is still no cure so far, which may make patient lose patience for long-term therapy. Furthermore, available specialties are insufficient, leading to a limited access to medical care and difficulty in seeking medical attention.

To address the abovementioned issues, insulin pump, a type of hardware designed for facilitating the blood sugar control of diabetic patients, is produced and composed of insulin reservoir, pump, power source and automatic analyzer of blood sugar. By an automatic analysis of the blood sugar level, insulin pump installed inside the patient's body may release an adequate amount of insulin into the patient's blood to regulate his/her blood sugar level. Bioartificial pancreas may provide the patient with numerous benefits, including a better life quality, a happier mood, no need for injection at every time, a peace of mind for shopping and eating out, not being afraid of low blood sugar level at midnight, prompt management for high blood sugar level, a stable control of blood sugar level, and the retardation of the occurrence of complication. In the other hand, there are also several disadvantages, such as expensiveness, monthly cost for consuming materials, and a weird feeling for having a foreign object inside the body.

However, the condition for a patient with chronic disease could be influenced to a certain extent by the disease, remedy, and mental condition, in addition to his/her physiological status. Therefore, we still could not identify any single indicator to be the ideal guideline for determining the reasonable dosage for an individual patient. The current way is still mostly depended on the clinical professional judgment and therefore, different medical staffs may adopt different medical remedies for the same patient. Even with the same medical remedy, patients may react differently. Since error related to manual judgment is inevitable and medical staffs may misjudge in some circumstances, investigations on issues on how to achieve an effective control of patient's condition, how to discriminate well- and poor- controlled patients and what are the features related to a poor control will provide significant and valuable assistance to patients, physicians and health education staffs.

With artificial neuromolecular networks, this article aimed to establish a model for the blood sugar level variation and administrated insulin dosage of one individual patient during a certain period.

Based on the establishment and study of this model, the relationship between the blood sugar levels and administrated insulin dosage will be explored and used as reference together with the clinical experience and professional knowledge of physicians for clinical diagnosis.

2. DIABETES CONTROL

In recent years, the continuously increased living standard, together with the changes in diet and living habits, the incidence of diabetes in Taiwan has been increased year after year and diabetes has become a leading disease in civilized countries with a global incidence of 190 million based on the statistics of Global Diabetes Alliance and blood sugar levels of 2/3 patients are not well-controlled. With various serious complications of cardiovascular, retinal, and renal diseases, diabetes may lead to enormous medical expense and social cost and become a serious burden of many countries. While patients facing this annoying diabetes, a cheerful mood is important and vital, and so is diet control and medication compliance.

For a healthy person, ingested food is digested and decomposed in the gastrointestinal tract to produce glucose, which is transported throughout the body via blood circulation. While passing the pancreas, glucose may stimulate the pancreas to release insulin and insulin may facilitate the entry of glucose into cells to be transferred into energy, or be stored in liver, muscles, and lymphocytes. Therefore, in the absence of insulin or the occurrence of insulin resistance, glucose could not be utilized and then sugar levels in the blood may rise. While the blood sugar level is increased to an extent over the recovering limitation of kidney, glucose will leak into urine to make the so-called diabetes. However, clinical studies indicated that the presence of glucose in urine is not the inevitable feature for diabetes and the current diagnosis criterion for diabetes is that the blood sugar level is higher than the upper limit of reference range. Diagnosis criteria adopted by general diabetes associations are as follow:

1) Two times of venous blood sugar level after fasting over 140 mg/dl

2) With a venous blood sugar level after fasting lower than 140 mg/dl, but the venous blood sugar level at 2 hours after oral administration of 75 mg glucose (glucose tolerance test) is over 200 mg/dl.

3) Frequently accompanied with the following classical complications, including more drinking, more urinating, and more eating, but still losing weight.

The following 4 types of diabetes have already been recognized by American Diabetes Association (ADA, 2006):

1) Type 1 diabetes: Accounting for 5-10% of total incidence, type 1 diabetes is normally due to insulin insufficiency caused by the damage of β cells. This type could be further subtyped to be immune mediated and idiopathic.

2) Type 2 diabetes: including patients due to primarily insulin resistance accompanied with relative insufficiency of insulin and patients mainly due to primarily insulin insufficiency accompanied with insulin resistance (accounting for 90-95% of total incidence).

3) Other specific diabetes.

4) Gestational diabetes mellitus (GDM): This type of diabetes is only detected during pregnancy. With a well control of blood sugar, the incidence of complication and the consumption of medical resource could be reduced.

From 1983 to 1993, National Institute of Diabetes, Digestive and Kidney Diseases (NIDDK) has promoted a Diabetes Control and Complication Trial (DCCT). With 1,441 patients with type 1 diabetes being study subjects, results from this trial have shown that the incidence of retinal disease was reduced by 76% if the blood sugar levels of diabetes patients were controlled within a reasonable range. Furthermore, the possibility for renal pathology was also significantly alleviated by reducing the incidence of micro albuminuria and proteinuria was reduced by 39% and 54%, respectively. Furthermore, the occurrence of clinically evident neurological pathology was reduced by 60%. In September of 1998, United Kingdom Prospective Diabetes Study (UKPDS) with 3,867 patients newly diagnosed with type 2 diabetes being the study subjects has discovered that the risk for diabetes-related complications, diabetes-related mortality, overall mortality of tightly-controlled group (with a HbA1c of 7.0%) was reduced by 12%, 10%, and 6%, respectively, as compared with that of loosely-controlled group (with a HbA1c of 7.9%). A strict control of blood sugar is particularly vital for the prevention of diabetes-caused small vascular pathology (reduced by 24%). A controlled analysis of blood sugar (A1c) for diabetes patients in New Orleans by has suggested that age is the most important variance, that is, age is the major factor affecting the condition control of diabetes. Results from this study revealed that the ratio of inappropriate A1c control of patients under 65 is 3.2 times of that of other patients. Furthermore, the ratio of inappropriate A1c control of patients under 55 is 4.1 times of that of other patients. These results indicated that younger patients were more careless about condition control.

The abovementioned results have clearly concluded that not only the physiological condition of patients, diabetes control is even more related to the psychological and population features. In other words, the impact of psychological index and social factors, in addition to psychological index, should be further investigated.

3. SYSTEM STRUCTURE

The ANM system has integrated the processing of intra- and inter-neuron information. Recently, functions for processing neuronal information have been gradually discovered. For examples, the second transmitter (cyclic AMP, cyclic AMP, calcium) may act as a controller for the neuron projection in the central nervous system (Liberman, et al., 1975). These theories stated that signals from certain information transmitters and regulators on the surface of cell membrane are transduced into signals of the second transmitters (cAMP), which may subsequently interact with some kinases. These kinases are responsible for the regulation of reactor proteins, such as proteins for controlling ion channel or connecting microtubule. These reactor proteins may directly or indirectly affect the opening of ion channel to affect the potential or transmission of neurons.

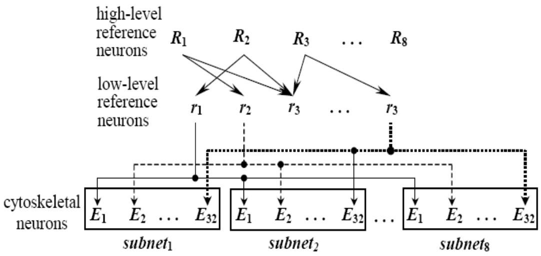
Liberman and other researchers (Liberman, et al., 1975) injected trace amount of cyclic 3"5"AMP into neurons to lead to a rapid increase of potential. They believed that cAMP may act at the microtubule associated proteins (MAPs) on the cytoskeleton in cell membrane, which then open the ion channel. Other researchers suggested cytoskeleton has a capability for signal (information) integration or memory function. Therefore, we may image the cytoskeleton of neuron as a multi-molecular network with microtubules, microfilaments, and neurofilaments and some proteins connecting these molecules (microtubule-associated proteins; MAPs). These MAPS have various functions, including the maintenance of neuron structure and interaction between cell membranes to control the cell shape, the facilitation of the circulation of certain micro-materials inside the neurons, and the regulation of other intra-neuron information processing.

So far, ways for intra-neuron transmission control and intra-neuron information processing are still not very clear and possible ways being considered include mechanical or sliding motions affecting the membrane tension, switch-like alternation of molecular structure, and alternation of stick-connection molecular structure. Detailed simulation of these movements will require a vast amount of calculation cost (computing time). ANM system emphasize on the investigation of system functions, therefore, we only simulate these neural information processing in a more focusing and abstract way. Cellular automation (Wolfram, 1983) is the most suitable to fulfill the purpose of this signal integration, since cellular automation may present the cytoskeleton in a simple and easy way. For examples, different component molecules in each cytoskeleton may express signals with different transmission speed and effect while MAPs may react differently to different signals. The alternation of these parameters may allow evolutionary system movement in many aspects, including transient and specific actions.

Only focusing on the inter-neuron network association, all traditional artificial neural networks do not pay any attention on the intra-neuron and chemical information processing. However, the operation way of ANM system is to transfers the information into intra- and inter-neuron connection and therefore this system has an additional capability for intra-neuron information processing, apart from information expressed through the inter-neuron network. The information processing ability of each neuron is based on the input/output information processor generated from an evolutionary learning and these neurons may self-compose to construct a coordinating information processing group. Without any doubt, ANM system may use one neuron to present and simulate what traditional artificial neural networks can do. Generally, evolutionary learning is not applicable for computer program. A slight change in a program may lead to a malfunction, since high peaks and low troughs in the adaption curve of a program are extreme with precipitous paths between peaks. Such precipitous feature of computer program could lead to a standstill during evolutionary learning and therefore make it especially unsuitable for evolutionary learning. A term of multidimensional bypass is used to describe ANM system (Chen and Conrad, 1994) since intuitionally one more dimension will increase the chance for saddle point to occur. To describe such intuition in a more formal way is the association between complexity and stability in an arbitrarily dynamitic system (Gardner and Ashby, 1970). The theory is based on that along with the increase of element number and interaction, the opportunity for saddle point occurring will be consequently increased while repeated and weak interaction is also vital. These evolutionary learning related factors will be implemented in the intra-neuron and even the entire ANM network architecture.

The ANM system was motivated from brain information processing with a feature of self-organizing learning based on a presupposition that the system has an artificial organism feature of gradual structure/function transformability. Being a computer simulation system, ANM system may provide a presentation way (system program) to acquire a capability similar to the compact structure of biological system and then to gain a feature of high adaptability and gradual evolutionary learning of biological organisms.

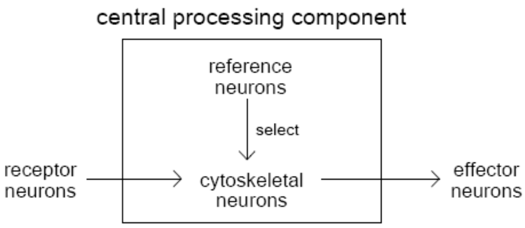
The establishment of ANM system is based on two presumptions. Firstly, intra-neuron information processing in brain is extremely vital since it may directly or indirectly affect the trigging actions of these neurons. Such neurons, called cytoskeletal neurons or enzymatic neurons, may combine together in a self-organization way and accept input information from different times and spaces to generate a series of output information for the control of outputs from other neurons or organisms. Secondly, some neurons, called reference neurons, have a capability to control other neurons. By integrating these two types of neurons, ANM system becomes a multi-layered artificial neural structure, which may generate effective operation and interdependent learning (Chen and Conrad, 1994). Furthermore, the adaptability and learning capability of ANM system may be enhanced according to the increased variety of components inside the cytoskeletal neurons or enzymatic neurons.



Picture 1: Architecture of ANM system

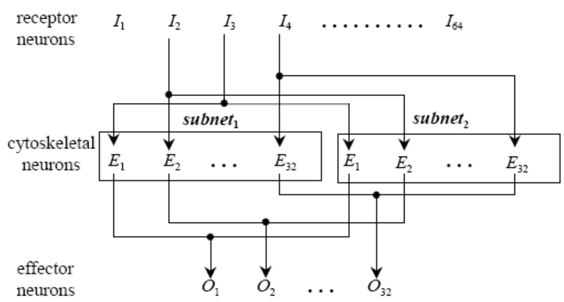
The main architecture of ANM system, composing of one group of reference neurons and cytoskeletal neurons (Picture 1), could be divided into 3 layers, including high-level reference neurons, low-level reference neurons and cytoskeletal neurons. The main function of reference neurons is the control or assembly of other neurons. Each cytoskeletal neuron may be seen as a specific input/output converter while the conversion of input information to output information is depended one the intra-neuron dynamics. For early ANM systems, cytoskeletal information processing was gathered in a way of cellular automation, based on a presumption that cytoskeleton may act as a role as information integration. The transmission of extracellular information into cytoskeleton will induce the circulating of certain cytoskeletal signals, which then may gather at a certain place to compose a certain signal combination. Eventually, this signal combination may affect one cellular enzyme, such as enzyme controlling the switch of ion channel, to enhance the intra-neuron potential and lead to a firing action.

A total of 256 cytoskeletal neurons were divided into 8 subnets with 32 neurons in each subnet. The connection of input/output interface of central processing component in ANM system is shown in Picture 2. The input/output interface is composed of receptor neurons and effector neurons. Cytoskeletal neurons and receptor neurons are connected in the same way in each subnet to ensure that each subnet may receive the same input signal from the same receptor neuron transmission. Similarly, cytoskeletal neurons and effector neurons are connected in the same way to ensure that organisms may act in the same way in response to the same output from each subnet.



Picture 2: The input/output interface of central processing component

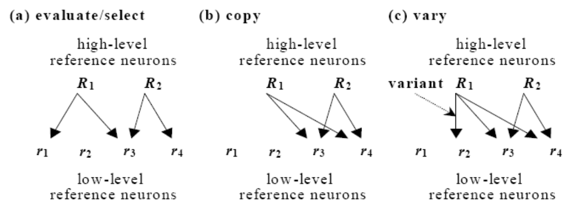
Detailed subnet input/output interface consists of 64 receptor neurons and 32 effector neurons (Picture 3). During the system configuration, each receptor neuron was connected to cytoskeletal neuron in a different and randomized way and therefore, each cytoskeletal neuron may receive information from different receptor neurons to become different input/output information processors. Along with learning process, these connections will be appropriately adjusted to fulfill the system requirements. However, effector neurons are connected with cytoskeletal neurons in a fixed way and then according to altered transmission of cytoskeletal neurons, system output will be changed subsequently.



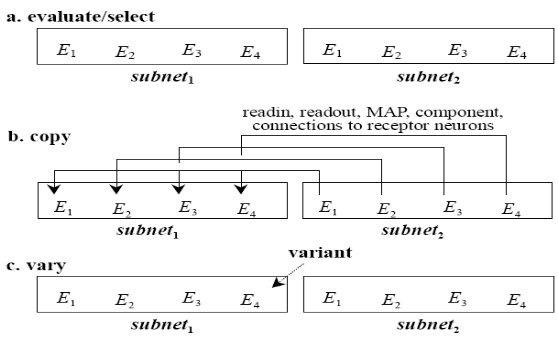
Picture 3: The subnet input/output interface of information processing neurons

As described above, cytoskeletal neurons in ANM system are divided into 8 subnets. In response to the same input, these 8 subnets will be initialized and evaluated sequentially. Several region networks with superior performance will be duplicated into those with inferior performance. With a variation-selection evolutionary search, evolutionary learning may consist of 3 steps, including evaluation and selection of subsystems with better performance, duplication of superior subsystems into inferior subsystems, and varied performance of inferior subsystems (Pictures 4 & 5).

The following description is about how to use two dimensional cellular automata to simulate the cytoskeletal information processing. In Picture 6, each grid presents a basic unit of cytoskeletal component and is indicated as C1, C2 or C3, based on the presumption that intra-neuron information transmission is conducted by 3 various components (microtubules 、 microfilaments and neurofilaments). Transmission features of these 3 components are different while the transmission speed of C1 is the slowest but the transmission energy is the strongest; the transmission speed and energy of C2 are both intermediate; and C3 has the weakest transmission energy but the fastest transmission speed.

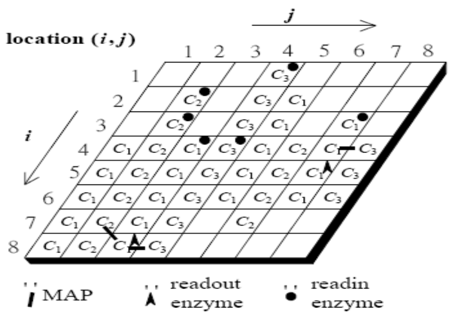


Picture 4: The evolutionary learning process of reference neurons



Picture 5: The evolutionary learning process of cytoskeletal neurons

Each unit could be a point for information input or output while input point is called readin enzyme and output point is named as readout enzyme. Readin enzyme is responsible for receiving the extracellular signals transmitted to cellular membrane and transferring these signals into molecular structure signals. While a signal combination arriving, readout enzyme is responsible for the firing of that neuron. However, there are some limitations on the configuration of readin and readout enzymes. Readin enzyme could be deployed on any component while readout enzyme could be only deployed on C1 component since it is believed that the firing of neuron is caused by one certain type of component.



Picture 6: Cytoskeleton of cytoskeletal neurons

Signals could be transmitted between the same types of components. While extracellular signals are transmitted to cellular membrane to open a readin enzyme, this readin enzyme simultaneously opens components at the same position. These opened components again affect neighboring same components and such continuous effect leads to a signal circulation of cytoskeleton. As shown in Picture 6, readin enzyme (2, 2) receives a signal and then activate C2 component to generate a signal moving along with C2 component from (2, 2) to (8, 2). During this process, activated components enter into a transient refractory phase right after the signal transmission in order to form a directional signal flow. During this refractory phase, this component cannot be activated again until the end of refractory phase to ensure one directional transmission.

Signals could also be transmitted between different types of neurons. On cytoskeleton, one type of connection protein (microtubule associated protein, MAP) is especially responsible for the connection between different components. Upon a contact with connection protein, signal of a certain component will be transmitted by this connection protein to a different component at the other end to induce an energy level change. Such energy change may produce a new signal circulating among components. For examples, readin enzyme at (4, 3) receives a signal to activate C1 component and then move to (8, 3) along C1 component. Two connection proteins at (8, 3) respectively connect to C2 at (7, 2) and C3 at (8, 4), to affect the energy levels at these 2 positions. Since the energy of C1 is bigger than that of C2 and C3, new transmission signals are generated individually on C2 and C3 components. However, if signal is transmitted from C2 at (7, 2) to C1 at (8, 3), new transmission signal is not necessarily generated on C1 component due to the difference in transmission energy levels of various components.

Table 1: Transmission energy level relations of various components

Neighboring component	Current component C1	C2	C3
C1	S	S	S
C2	I	S	S
C3	W	I	S

S：Strong I：Intermediate W：Weak

In the ANM system, to ensure the capability of cytoskeleton to integrate signals from various times and spaces, it is presumed that various components possess different energy impact. Energy association decides the difficulty level for a component activation (components with higher energy levels are easier to be activated), as well as the signal transmission time between components and signal combination required by neuron firing. Transmission energy level relations of various components are shown in Table I to indicate the impact of the neighboring component to the current component. For each component, the energy has to reach S (Strong) level to be activated to generate a signal movement. For the precedent example, signal was transmitted from C2 at (7, 2) to C1 at (8, 3) without generating any new transmission signal since the energy level is under S. However, the energy level of C1 is raised to I (intermediate), indicating a nearly activated state. With a timely signal from C3 at (8, 3), the energy level of C1 may possibly be raised to S and then signal movement of C1 will be activated. In the other hand, without any timely signal, energy of C1 will gradually vanish along with time.

Furthermore, transmission energy levels among the same components are all S, like C1 to C1, C2 to C2, and C3 to C3, which could be due to the particular relationship between the same components to easily open each other, despite of the different energy levels of C1, C2, and C3. This is the reason for this type of energy level being define as S and the reason for the signal transmission between the same types of components.

As described above, once a signal combination reach readout enzyme, that particular neuron will fire. Cytoskeleton has a capability to integrate signals from various times and positions. For examples, C1 at (8, 3) may simultaneously connect to C2 and C3 through two connection proteins to generate 3 different sets of signal combination at C1 to induce the neuron firing, including C2 signal activated by (2, 2) or (3, 2), C1 signal activated by (4, 3), and C3 signal activated by (1, 4) or (4, 4). Among C1, C2, and C3, the moving speed is different and required time for signal integration is different and subsequently, the time required neuron firing is different.

For the adjustment of neuron transmission behavior and assembly of neuron groups, the evolutionary learning of ANM system takes place at 5 levels:

1) at readin enzyme: controlling the activation point of the initial signal,

2) at readout enzyme: controlling the point of integration of response signals (indirectly control the neuron firing),

3) at cytoskeletal components: controlling the signal pattern on cytoskeleton

4) at connection protein: controlling the impact of signals between various components,

5) at reference neurons: controlling or combining various neurons to accomplish one particular assignment.

The first 4 levels are intra-neuron evolutionary learning (internal dynamics) and the fifth level is inter-neuron evolutionary learning. For the current system variation, only one level is altered in one variation cycle and another level will only be altered after several cycles of learning. With such cycling procedure, learning of each level may sequentially conducted.

4. STUDY DESIGN AND RESULTS

Medical information of 4 inpatients in the Department of Endocrinology and Metabolism, Taichung Hospital were collected for ANM study. Collected information, a total of 191 sets of data, are observation data during the hospitalization of these 4 patients, including blood sugar levels and administrated insulin dosage during a continuous period.

4.1 Data normalization

With different data scales, the significance of values in various categories may be quite different. To eliminate such discrepancy in this study, data of various categories were normalized to one scale of 0-1. For normalization, the upper and lower limits of one category (which is higher and smaller than the maximum and minimum of that category, respectively) were defined and then all values of this category were reduced proportionally to 0-1. The number of cytoskeletal neurons used was 40, together with 9 sets of CPS and the signal intensity of category input was set at 0.6. Firing requirement was set as at least 2 signal interacting at readout enzyme and a signal intensity higher than 1.001 for the firing to occur.

After data normalization, 2/3 of data set was partitioned into training data set and 1/2 into test data set. Training data set was input the ANM System for an analysis at learning stage to establish a prediction model for insulin dosage. Established prediction model was used for a pre-test with test data set (testing) to obtain the prediction accuracy of insulin dosage.

Table 2: Results from 5 sets of individual training and testing with ANM system

Patient		Set1	Set2	Set3	Set4	Set5	Average
A	Training	92.0%	84.0%	88.0%	92.0%	88.0%	92.0%
	Testing	86.7%	100.0%	93.3%	86.7%	93.3%	88.8%
B	Training	90.0%	85.0%	85.0%	85.0%	80.0%	87.5%
	Testing	75.0%	87.5%	87.5%	87.5%	100.0%	85.0%
C	Training	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%
	Testing	92.3%	0.92.3%	0.92.3%	100.0%	100.0%	95.4%
D	Training	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%
	Testing	96.4%	100.0%	92.9%	96.4%	100.0%	97.1%

4.2 Experimental results

The system has established a model for each patient. To avoid the interference rising from the data partition for training and test data sets, randomized sampling was conducted to generate 5 sets of training data set and test data set with various number order. The model establishment and testing was performed with these data sets (Table 2). In the individual training mode, the training results of 4 patients were between 87.5 – 100%. With individually established model for testing, the prediction accuracy was between 85.0 – 97.1%. From these results, it was discovered that testing results with individual training model have a higher accuracy for predicting the disease severity.

To further determine if these results are acceptable or lower than expected, the same set of data were subjected to analysis with SVM (non-linear classification) and decision tree (J48). A comparison of results from various analysis methodologies was shown in Table III.

Support Vector Machines (SVM) is one type of classification algorithms, one novel machine learning method derived from statistical learning theory by Vapnik in Bell Laboratory (Scholkoph and Smola, 2000; Vapik, 1995). The theoretical basis of SVM classification is to identify an optimal separating hyperplane (OSH) among a high resolution space to partition data for a maximum border between separated two category data. This study has adopted free software developed by Professor Chin-Jen Lin and his team, National Taiwan University to resolve some problems including convergence proof. After multiple parameter adjustments and combination of gamma and cost, SVM results of training set data were all over 92.31% and tests with individually established model showed the prediction accuracy were all higher than 80.00%, and even as high as 92.86%.

As for analysis with decision tree, this study adopted a free software decision tree J48 in the Weka (The Waikato Environment for Knowledge Analysis) version 3.4, in the way similar to that of Quinlan C4.5 (1996). After multiple parameter adjustments, a parameter of J48 -C 0.25 -M 2 adopted. Results of decision tree J48 with training data set were all over 96% and tests with individually established model showed the prediction accuracy were all higher than 75.00%, and even as high as 85.70%.

These results (Table 3) have shown that results of ANM system were closer to that of SVM, as compared with decision tree J48. From the comparison of results from SVM and decision tree J48, it was indicated that the prediction capability with an established model of ANM system is acceptable and the performance of ANM system in the prediction of insulin dosage is satisfactory.

Table 3: Comparison with other tools

Patient	ANM		SVM		Decision tree (J48)	
	Training	Testin g	Training	Testing	Training	Testing
A	92.0%	88.8%	100.0%	100.0%	96.00%	85.70%
B	87.5%	85.0%	95.00%	85.00%	100.0%	75.00%
C	100.0%	95.4%	92.31%	88.46%	96.15%	80.00%
D	100.0%	97.1%	96.43%	92.86%	98.21%	82.86%

5. CONCLUSION

Based on retrospective data and a self-organizing learning, this study has conducted a data mining for physiological conditions and diabetes control of patients with various population features. Results from this study will provide valuable help to clinical management, administration, teaching and research.

This study started from physiological condition and laboratory data of patients, medical procedures conducted by medical staffs, to the medical results and dosage from artificial pancreas. With a self-organizing learning and data mining of medical procedures and patients' condition, this study has evaluated the artificial intelligence system, which may self-learning from real data to assist the physicians in deciding the most suitable insulin dosage for diabetes patients. Data analysis has been conducted in various ways to discuss the effective decision and control for patient's condition. Results indicated that the ANM system may be of great help in obtaining an acceptable condition evaluation, which may effectively facilitate the physicians in deciding the most appropriate insulin dosage for patients with artificial pancreas to alleviate the pressure from physicians and promote the quality of medical care.

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