THY-SYS: A PRELIMINARY THYROID WELLNESS ASSESSMENT THROUGH MACHINE LEARNING USING PATHOLOGICAL FACTORS

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CERTIFICATE OF OWNERSHIP/ORIGINALITY

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APPROVAL SHEET

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ABSTRACT

The thyroid gland, which belongs to the endocrine system, is a butterfly-shaped organ at the front of the neck that plays a critical role in an individual's overall health and well-being. According to a survey, thyroid dysfunction is observed in 8.53% of Filipino adults aged 42 to 62 years old, implying that 1 out of 12 Filipino adults has some form of thyroid function abnormality. To promote awareness of thyroid health, the researchers developed the Thyroid System for Wellness Assessment (Thy-Sys) which aims to determine the wellness of a person's thyroid through machine learning. The system assesses the user's thyroid wellness based on their responses to questions related to observable characteristics of the more common thyroid diseases like hypothyroidism and hyperthyroidism. Before the development, four machine learning models, Support Vector Machine (SVM), K-Nearest Neighbors (KNN), Decision Tree, and SVM-KNN were evaluated in classifying the state of the thyroid through pathological factors. Training and testing of the machine learning models were done over a data set with 1,464 entries and a total of 18 pathological attributes. 10-fold cross-validation was performed to verify the models' accuracy while observing other metric scores. The SVM-KNN model garnered the highest accuracy of 99.55% with 98.75% precision, and 98.61% recall and F1 scores, and was integrated into the system.

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CHAPTER 1
INTRODUCTION

The first chapter of this paper provides the context, under which the study was made, and describes the problems which motivated the conduction of this study. In addition, this section also expounds on the intention of trying to address a problem as well as the relevance of such effort and the output produced consequently to the analysis and inquiry.

1.1 Rationale of the Study

Most people place great emphasis on their health because of what it entails and its implications on one's body. However, defining exactly what health is can be difficult. Most have a good general idea of what "health" means, but there is no absolute definition of *what it is*. Rather, health is defined in terms of what it is not. Simply, health is when the body is not ailing with diseases or discomfort ("Health", 2002). In addition, according to the World Health Organization (2021), health comprises the entirety of one's condition, and not just the absence of illnesses or infirmity, thus including the physical, mental, as well as social well-being of a person.

Prior to the COVID-19 pandemic, it has been a common observance that several people avoid utilizing and availing of the different public healthcare services. A study by Taber, Leyva, and Persoskie (2015) shows an assessment of the reasons why this trend is so. Through a conducted survey with the general public in the U.S., reasons for avoiding medical care were categorized, with emphasis placed on three major categories - the low perceived need for medical care, traditional barriers from obtaining such care, and unfavorable evaluation when it came to seeking medical care. Among the main reasons falling under the category of low perceived need, the top reason for avoiding medical care was the basis that the encountered medical problems could "heal over time" or "heal on their own", with "not sick enough" coming as the second reason. But, it is also worth noting that other factors, like medical expenses, and personal and

interpersonal issues are also determiners of this trend. But because of advancements in the medical field, the purpose and aim of medical care have also evolved. Now, seeking medical professionals and their help has become a form of preventive healthcare where it is taken as an opportunity to learn more and be educated enough to know what to do in case of unfavorable diseases or conditions - this would not have been the case years ago when seeking medical professionals ultimately meant that one was sick (“The Importance of Regular Checkups”, 2019).

One of the important systems of the body is the endocrine system. It is a unit of different glands located all over the body - glands that secrete chemicals called “hormones” that enter the bloodstream, traveling to other parts of the body. The different endocrine glands in the system can be either classified as the brain part responsible for allowing the rest of the glands to function, the pituitary gland part, or the (non)target endocrine gland (Kumar, et al., 2018). Generally, the endocrine system is vital to the bodily functions of a human because it helps in regulating the homeostasis as well as the difference in the body’s reaction to different internal and external stimuli (Hiller-Sturmhöfel & Bartke, 1998).

The thyroid gland may be a 2-inch butterfly-shaped organ at the front of one’s neck, but is a major gland in the endocrine system which affects most, if not all, organs in the body. It is the gland that controls fat and carbohydrate metabolism, breathing, body temperature regulation, cholesterol levels, the heart and nervous system, levels of blood calcium, menstrual cycles, the integrity of the skin, and even brain development (Harris, 2012).

One of the most common disorders of the endocrine system is thyroidal. The hypothalamus, classified as the brain part of the endocrine system, is responsible for the production of the thyrotropin-releasing hormone (TRH), signaling to the pituitary for the release of thyrotropin, also called the thyroid-stimulating hormone (TSH), which, in turn, stimulates the thyroid to produce the thyroxine (T4) and triiodothyronine (T3) (Hiller-Sturmhöfel & Bartke, 1998). One thyroid disease called hypothyroidism is usually the result of the lack

of iodine in the body obtained through one's diet. On the other hand, another kind of thyroid disease is called hyperthyroidism, which comes as a result of an overactive thyroid. Hyperthyroidism is commonly caused by Graves' disease, an autoimmune condition whereby the TSH is activated because of an antibody produced by the immune system that attaches itself to the receptors of the TSH, thus causing it to become overactive (Norris, 1998). The risk of thyroid diseases is dependent on the lifestyle of an individual (Huang, Y. et. al, 2019) and whether or not there is a family history of thyroid disease. As a point of consideration, thyroid diseases typically have various visual manifestations such as how symptoms of hyperthyroidism may consist of high blood pressure, diarrhea, rapid heart rate, and weight loss and how hypothyroidism is associated with fatigue, dry skin and hair, and weight gain (Harris, 2012). In an interview with Junjie Caber, RMT, MPH, the Chief Nuclear Medicine Technologist PSH at the Nuclear Medicine Clinic at Perpetual Succour Hospital (Appendix B, Transcript of Interview with Ms. Junjie Caber, RMT, MPH), these pathological factors, among others, are why physical/preliminary assessments and medical consultations are important. While it does allow medical professionals to have an idea of what a person may be experiencing, it, more importantly, allows medical experts to recommend the appropriate laboratory test(s), which can officially confirm what a person may or may not be experiencing. This, in turn, allows the medical expert to provide the appropriate treatment afterward. A study of the prevalence of thyroid diseases in the Philippines conducted by Carlos-Raboca, et al. (2012) shows that among a total of 4897 whose thyroid functions were tested, 8.53% of whom had thyroid dysfunction, with 2.18% and 0.4% having subclinical hypothyroidism and true hypothyroidism, respectively, and with 5.33% and 0.6% having subclinical hyperthyroidism and true hyperthyroidism, respectively.

In addition to the more common thyroid diseases, there can be other concerns regarding the thyroid/ For example, nodules may also be discovered through self-assessment, or through clinic visits and imaging procedures. In fact, it is common. However, most of these nodules are benign, but in rare cases, can become malignant (Popoveniuc & Jonklaas, 2012). If in the process of

assessment, the presence of nodules raises concern, then it should be taken to the doctors, regardless of whether they end up being benign or malignant.

This type of response is shown through the responses in an interview with the members of THYCA Fighters, a thyroid cancer support group (see Appendix B). Initial self-assessment was the primary reason these survivors sought medical attention. In the case of Ma'am Sansen Cafe and Ma'am Lucila Francisco, both of them felt a hard lump on their throat and were then diagnosed with Papillary Carcinoma through a biopsy and had to have a thyroidectomy. On the other hand, Ma'am Marlina Verdida claimed to have had trouble with breathing, initially leading them to believe it was caused by high blood pressure or heart disease - this turned out to be negative according to her testing. However, when recommended to take a thyroid ultrasound, her results showed a small mass in her air pipe, leading her to have a thyroidectomy. There have been cases when THYCA fighters and their relatives claimed to have felt a lump on their throat only for their laboratory test results to come back negative. Only last year, Ma'am Lucila reported another lump on her throat, but her bloodwork and biopsy showed negative results. Results of the CT scan also came back negative. Similarly, Ma'am Sansen's sibling also felt a lump on their throat with biopsy reports showing it was benign. In addition, Junjie Caber also states that these scenarios can be frequent, but should not be seen as a waste of time or money since it provides people the relief of not having a serious medical condition - a sentiment shared among Ma'am Sansen, Ma'am Marlina, and Ma'am Lucila.

The current circumstance which encourages most citizens to stay at home has put a strain on the availability of direct access to physical checkups, thereby impacting the confidence of individuals in visiting medical establishments who seek appropriate medical advice. Moreover, it has placed emphasis on the need to maintain one's well-being.

Having been inspired by an existing study, the researchers sought to extend the said study that used machine learning algorithms in the prediction of

thyroid diseases by creating an initial self-assessment system, which uses established machine learning algorithms in the evaluation of an individual's thyroid wellness.

1.2 Statement of the Problem

1.2.1 General Objective

This research aims to develop a thyroid wellness system using a machine learning model based on pathological factors.

1.2.2 Specific Objectives

1. Determine and verify the pathological factors considered in the prediction of thyroid diseases
2. Design and develop the SVM, KNN, Decision Tree, and SVM-KNN models to be used by the system in identifying the presence and kind of thyroid disease, and test and determine the accuracy and performance of the models obtained
3. Develop the system using the model showing the best performance among all the other trained models.

1.3 Significance of the Study

The outcomes of this study may be relevant and instrumental to the following parties:

General Public. The aim of the system is to help people become more aware of the medical services and the importance of having oneself checked by doctors. Moreover, it promotes awareness of one's health. By using the system, one is encouraged to get medical assistance when concerned about feeling certain symptoms, specifically ones that concern the thyroid.

Doctors and Medical Professionals. More than just promoting awareness of one's overall feelings and disposition, the system can also serve as an assistive system to doctors when patients, who have used the system, go to the doctor's office for checkups or examinations. Because the specific symptoms

have already been collected, more time can be spent by the doctors to further clarify patient reports in order to determine the series of actions and tests to be taken.

Medical Field and Healthcare Industry. Numerous efforts have been put into trying to predict the presence of thyroid diseases with the aid of computer and machine learning systems. The system does not serve as a substitute for clinical diagnosis, rather as a support for assessment and as an aid in the process of actual diagnosis, potentially serving as a preliminary evaluation in the new normal mode of doing activities.

Researchers. The creation of said system serves the best interests of the researchers by providing an avenue to hone and develop practical skills in designing and producing innovative and useful systems and provide practical use of computer algorithms in addressing problems observed in the community.

Future Researchers. The study opens an avenue for further developments within the field of study and may serve as an entry point for another research topic, particularly in the field of Computer Science and Medicine.

1.4 Scope and Limitation

The study intends to address the new normal circumstances where going to the doctor's office requires a specific set of protocols to be followed, as well as the inability of some people to be able to go out at this time of the pandemic. The system will assist the individual in the self-assessment of thyroid wellness. It is not meant to replace medical diagnosis, but rather, encourages individuals to seek medical attention when necessary. The study chooses one among SVM, KNN, Decision tree, and SVM-KNN machine learning models to employ into the system to predict the state of thyroid wellness based on 18 pathological factors. Indication of the presence or absence of thyroid dysfunctionality shall be made known to the individual, so that an appropriate medical response may be in order.

In addition, the results produced based on the user's responses to the questions are not diagnostic and are not absolute, but are evaluations of the wellness of the user's thyroid. It shows how the user may or may not have thyroid disease, according to the factors considered in the algorithm.

The data set used in the training and the testing of the algorithm contains 1464 entries. Moreover, the study specifies thyroid diseases to be hyperthyroidism and hypothyroidism.

CHAPTER 2
REVIEW OF RELATED LITERATURE

This chapter reviews literature from various scholars, which expound on the different uses of machine learning in the field of medicine. Furthermore, this section of the study evaluates and examines how numerous prior studies have used different algorithms, particularly with the aim of trying to predict different diseases, and the relevance of the result of such studies to the creation and completion of the current study.

Computer and Medicine

Technological advancements like information and database management systems provide convenience and efficiency in the manipulation and accessing of records and other sets of data. A study by Mehta, Deb, and Rao (1994) seeks to establish how crucial and beneficial computer techniques are in the field of medicine, health, and services offered by hospitals. Moreover, Computer Assisted Decision making (CMD) have also provided doctors assistance in providing better diagnosis, prognosis, and remedies. This allowed for faster analyses of blood samples and microorganisms, a critical advantage in data retrieval and therapy

Furthermore, within the healthcare and medical industry, the demand for the use and integration of newer technologies is great. Besides using computers to digitally store patient data, medical simulation has also been one of the practical uses of technology. Medical simulation has become relevant by allowing practicing professionals to emulate scenarios and the course of action to take in each case - ones that cannot always be done when dealing with real patients (Lavoie and Clarke, 2017, as cited in Papp, Deeb, Booth, El-Sayed, & Freilicher, 2018). In a study conducted by Papp et al. (2018), systems resulting from the advancement of engineering and computer science are manifested in various ways in the field of medicine - the use of technology in emulating soft tissues in the human body for more realistic mannequins, as well as ultrasound simulations, and even giving students opportunities to be able to simulate the

environment and experience of being a surgeon through virtual operations. These uses show that technology in medical practice has become more and more significant by providing students the means to participate in scenarios that mirror real-life and further enhance training.

In addition, there is a growing recognition of the usefulness of artificially intelligent systems and machine learning to physicians as such systems not only have the potential of doing a physician's work more accurately and efficiently but also promote the safety of patients (Bajema, 2021).

To demonstrate, a study by Giannoula, et al. (2020) assessed the feasibility and applicability of developing an application for Patients with Differentiated Thyroid Cancer (DTC). This had the intention of developing a platform that provides timely information regarding DTC, including a section for medical records and a notification system for pill prescription, follow-up tests, and doctor visits reminders, thus focusing on educating the patients on Thyroid Cancer (TC), and monitoring patients remotely and improving their quality of life (QoL).

Telemedicine, because of the pandemic, has become one of the means for patients to communicate with their doctors regarding questions, follow-up checkups, and consultations, characterized by synchronous telehealth services. A model of the digital clinic is proposed called the mindLAMP (Learn-Assess-Manage-Prevent), whereby mobile devices and applications are utilized for continuous asynchronous care. It does not replace the traditional face-to-face administration of healthcare but supplements it by logging user conditions and activities, providing health tips and information, and even the option of chatting with the virtual care teams. With more affordable mobile gadgets, it makes sense to utilize them in ways that take advantage of the current circumstance (Rodriguez-Villa, Rauseo-Ricupero, Camacho, Wiśniewski, Keshavan & Torous, 2020).

Existing Methodologies (Related Technology/System)

Imaging tests have been a common tool for distinguishing areas where cancer cells may be developing and where they may or have spread. These imaging tests range from ultrasound, radioiodine scan, Chest x-ray, and Computed Tomography (CT) scan, to name a few. A biopsy is also a viable method, involving the removal of certain cells from an area to be analyzed. Blood tests and vocal cord exams are also viable options (American Cancer Society, 2021).

In addition to imaging tests, Raj (2014) notes that blood tests are also done in determining current levels of hormones in the bloodstream. Thyroidal diseases, in particular, are determined by the excess or lack of hormones produced. Tests like these require blood to be drawn and concentrations of the hormones are observed (“Thyroid Blood Tests”, 2019).

Predictive Technology

Technological advancements have been applied in various ways in the area of medicine. In 2016, the use of AI has become a notable phenomenon in the medical field, with its objective of automating the diagnoses of various diseases, relieving part of the doctor’s obligations, and redirecting more time to activities that require attention and cannot be automated (Buch, Ahmed & Maruthappu, 2018, as cited in Battineni, Sagaro, Chintalapudi & Amenta, 2020).

Battineni, et al. (2020) assess the use of machine learning predictive models in diagnosing chronic diseases (CD). The paper notes support vector machines (SVM), logistic regression (LR), and clustering as the machine learning techniques that have been commonly used among others across 453 papers published between 2015 and 2019. The accuracy of the predictions of diseases made based on the model(s) used was also realized, with the prediction of heart diseases, using the Naïve Bayes (NB) and SVM models garnering 84% - 91% accuracy. The authors have also noted that while biomedical networks and technologies have made it possible to analyze large amounts of data at a time, their accuracy is also reliant on the quality of the medical data obtained.

In addition, Kourou, Exarchos, Exarchos, Karamouzis, and Fotiadis (2015) note the growing trend of the application of machine learning methods in cancer research. Among these methods, Artificial Neural Networks (ANNs), Bayesian Networks (BNs), Support Vector Machines (SVMs), and Decision Trees (DTs) were the notable machine learning techniques that have been widely applied in cancer research and predictive models with a majority providing accurate results. Moreover, the paper focuses on the analyses of other researches within the last five years (from when the study was conducted), which highlighted the use of various ML techniques. Among the published works analyzed were the use of ML in determining the susceptibility of breast cancer, utilizing mammographic images and ANNs, ML in the prediction of the recurrence of cancer, and in the evaluation of the likelihood of cancer survival. Like Battineni, et al. (2020), emphasis is placed on the significance of having quality data sets and the conscious selection of features to be used in the development for a more accurate prediction as well as more effective use of ML techniques.

Moreover, the use of a decision tree-based data mining technique for early detection of breast cancer is presented by Sumbaly, Vishnusri, and Jeyalatha (2014). The study involves the use of a UCI's breast cancer data set in different classifying algorithms, including J48, C5, and CHAID among others. This technology was thought to be advantageous because the earlier the cancer is detected, the more likely it is to be cured. The study concludes that the technique through J48 classifiers with feature selection is the optimal technique to be utilized for breast cancer diagnosis, with 94.5637% accuracy in classifying tumors as benign or cancerous, indicating that machine learning can be viable for further use in the field of medicine.

The process of detecting blood diseases has now adopted the use of various data mining techniques in detecting and addressing such diseases at an early stage. This was presented in a study by Shurrab and Maghari in 2017. Using complete blood count (CBC) characteristics, three classifiers were employed in the study namely DT, rule induction (RI), and NB. These were used

in classifying blood diseases such as hematoma, both in adults and children and tumors. The results of the study showed DT having the lowest detection accuracy. On the other hand, NB was able to accurately detect blood tumors with a 56% accuracy rate, while RI had a higher accuracy rate than the other two techniques in the prediction of hematoma in children and adults (57% - 67%).

Computers have been of use in the field of medicine, especially when it comes to making decisions, diagnoses, forecasts, and predictions of diseases using various considered factors and conditions. A study by Hamsagayathri and Vigneshwaran (2021) reviews the ways by which machine learning has been used in the prediction of diseases based on their symptoms. The study has tabulated ten papers, ranging from the year 2009 to 2019. The subject of these studies focused on using different machine learning techniques to predict diseases, ranging from heart disease to liver disease, to diabetes, and dengue. Of the machine learning techniques used, SVM garnered the highest accuracy of 94.60%. In addition, the paper notes the use of Random forests, Naive Bayes, K Star, Artificial Neural Networks (ANN), and SVM, and their accuracy ranged from 70% to 90%.

Furthermore, Chauhan, Naik, Halpati, Patel, and Prajapati (2020) aimed to create a system called the “AI Therapist”, which attempts to predict diseases according to their symptoms. A CART decision tree algorithm was used by the system. The performance of the model was measured in terms of its accuracy, which was able to obtain 90.12% before preprocessing, and 93.85% after preprocessing.

Similarly, Keniya, Khakharia, Shah, Gada, Manjalkar, Thaker, Warang, and Mehendale (2020) aimed to create a model that can predict diseases according to the disease’s symptoms, as well as the patient’s age and sex. Using trees, NB, and various types of KNN, weighted KNN was found to obtain 93.5% accuracy in its prediction, allowing the model to act as an early doctor in the diagnosis of a disease.

Advancement of Predictive Technology in Thyroid Studies

An expert system by Keles and Keles (2006), called the Expert System for Thyroid Disease Diagnosis (ESTDD) diagnoses thyroid diseases. Using the data set for thyroid diseases from the UCI repository and a neuro-fuzzy hybrid method, ESTDD had a 95.33% accuracy in predicting thyroid diseases, utilizing data set from the UCI repository. Using a neuro-fuzzy hybrid method, ESTDD had a 95.33% accuracy in predicting thyroid diseases, considering five features of the data set: trd_1 (percentage of T3-resin uptake), trd_2 (total T4 hormones), trd_3 (total T3 hormones), trd_4 (total TSH hormones), and trd_5 (the absolute difference between the initial amount of TSH and the current amount of TSH post-administration of TSH-releasing hormone). Notably, the study aimed to provide assistance to doctors even with limited expertise in computers. The process of feeding data and obtaining results can be done individually (per-patient) or by batch (through files or through the total data in the database). More than that, both authors also suggest how information collected may be a valuable educational tool for students studying endocrinology.

In addition, there have also been comparative studies that seek to find which technique is best suited for thyroid disease prediction. Begum and Parkavi (2019) conducted a study involving different data mining and classification techniques to detect thyroid diseases. The study introduces the relatively lengthy and complex task of diagnosing a patient for thyroid disease, pertaining to the series of blood tests after performing a clinical examination. Thus, the early diagnosis of thyroid diseases is addressed through the use of various data mining techniques, specifically, decision tree algorithms (ID3), KNN, NB, and SVM, in the proposed model.

On the other hand, Tyagi, Mehra, and Aditya Saxena (2018) conducted an evaluation of the different machine learning algorithms, support vector machines (SVM), KNN, and DT, in their efficiency in terms of diagnosis. The study utilized data sets from UCI, however only considering only eight (8) of the twenty-one (21) attributes from the original data set. This resulted in SVM having

the highest accuracy rate of 99.63%. Similar results were also obtained by Duggal and Shukla (2020) in their study of predicting thyroid diseases among three ML techniques (SVM, NB, and Random Forests). Likewise, classification models created by Shankar, Lakshmanaprabu, Gupta, Maseleno, and de Albuquerque (2020) using a multi-kernel SVM, garnered accuracy, sensitivity, and specificity of 97.49%, 99.05%, and 94.5%, respectively.

Along with studies that involve the classification of thyroid diseases by pathology, predictive technology that uses SPECT (Single-Photon Emission Computerized tomography) images to diagnose a thyroid for a particular disease has also been considered. Ma, Ma, Liu, and Wang (2019) have developed a computer-aided diagnosis of thyroid disease by using convolutional neural networks (CNN). The said system was used to diagnose Grave's disease, Hashimoto disease, and subacute thyroiditis. By applying modified DenseNet architecture and flower pollination algorithm, the performance of the modified model was more than satisfactory over other CNN models.

Mir and Mittal (2020) propose a hybrid machine learning framework for the prediction of Thyroid Diseases. Using data sets collected from the SMS hospital which contained both pathological and serological attributes, the hybrid model, using the Bagging algorithm, garnered 98.56% accuracy in its prediction using both serological and pathological features.

Furthermore, Dharmarajan, Balasree, Arunachalam, and Abirmai (2020) uses data on patients' blood samples in order to differentiate thyroid disease diagnoses. Results of the study showed that the decision tree garnered the best accuracy with 97.35%, followed by SVM with 95.3%, KNN with 94.2%, and Naive Bayes with 91.62%. It is also worth noting that this study mentions that symptoms such as weight loss or gain, swollen neck or goiter, change in heart rate, hair loss, diarrhea, and menstrual irregularities are symptoms of thyroid diseases which harkens back to the attributes utilized by Mir and Mittal (2020).

In addition, the use of thyroid hormones T3, T4, and TSH in another study by Yadav and Pal (2019) sought to determine the thyroid conditions hyperthyroidism, hypothyroidism, and euthyroid through a J48 classifier decision tree, Random tree, and Hoeffding. These provided accuracies of 99.12%, 97.59%, and 92.37% respectively. Through the use of an ensemble technique, they were able to provide relatively better accuracy of 99.2% with a sensitivity of 99.36%.

Studies on SVM-KNN Optimization

The SVM is one of the more commonly used machine learning algorithms which garners satisfactory results. However, it is not uncommon that researchers use another algorithm to use together with SVM in order to optimize its performance. For example, a study by Li et. al. (2007) utilizes an SVM-KNN method to create a model used in solar flare forecasting. The results of the study show that the hybrid method improves the performance of a stand-alone SVM method which is proven by the SVM-KNN method having a higher accuracy than that of the SVM system and a Neural-based network method.

In another study by Li, We, and Shi (2002), the SVM classifier is used in a mixed algorithm. The mixed algorithm, SVM-KNN, works by classifying the test sample using SVM if the distance is larger than the stated threshold. Otherwise, the KNN algorithm is used. The results of the study showed that a mixed algorithm not only improves the accuracy of an SVM model but also provides better means of selecting the SVM kernel function parameter, thereby optimizing it.

CHAPTER 3
TECHNICAL BACKGROUND

This chapter contains the definition of the technical terms used in prior chapters or to be used in the upcoming chapters. The said terminologies shall range from terminologies in the field of Computer Science and the field of Medicine.

Homeostasis

According to Britannica (2020), homeostasis is the body's means by which internal processes are regulated, so that the body remains stable and optimal conditions vital to bodily functions are observed and maintained. This is done through a constant loop of feedback mechanisms, where adjustment is made in the body's internal and external conditions depending on the feedback it receives.

Hyperthyroidism

Hyperthyroidism is a condition in which an overactive thyroid gland produces an excessive amount of thyroid hormones that circulate in the blood (American Thyroid Association, 2021).

Hypothyroidism

Hypothyroidism is the condition when not enough thyroid hormones are produced by the thyroid gland so that the thyroid hormone levels are low (American Thyroid Association, 2021).

Pathological Factors

According to the Merriam-Webster Dictionary (2021), the term "pathological" is an adjective used to describe something that is suggestive of a particular disease. The word "pathological" has the root word "pathology", whose etymology is derived from the Greek word *pathos*, meaning disease. Pathology was a study of the change in the cells and tissues because of a disease. Pathological conditions, then, are not diseases but are abnormal physiological conditions that may be an indication of a particular disease (Porth, 2005).

Serological Test

Serology is a part of medical science which deals with the study of blood, particularly blood serum for the purpose of examining its properties. (“Serology”, 2021). Serological tests are tests performed to measure and determine the immune system’s response (World Health Organization, 2021) to different substances that can trigger infections, sicknesses, and diseases (Biggers, 2018).

Database

Data is a collection of facts obtained from an object or a group of objects with the purpose of being studied to create something meaningful and useful (“Data”, 2021). A database is a collection of data, organized in a systematic manner for the ease of retrieval, management, and manipulation (“Database Defined”, 2021).

Predictive Technology

Predictive technology is a branch of Data Science that consists of a set of tools that allow the forecasting and discovery of the likelihood of something happening and future trends based on a set of data obtained from the past through the analysis of previous and current trends and patterns. It has been used in various ways such as weather forecasting and analyzing trends in stock and investments (“Predictive Technology”, 2021).

Data Set

A data set is a collection of data, usually observations, with discrete values of attributes that describe each instance of data in the set (Nelson, 2020). For example, a person may be defined in terms of age, gender, and nationality.

Algorithm

An algorithm is a term commonly associated with computers and refers to a series of detailed and step-by-step processes taken to obtain an intended result or solve a specific problem, usually referring to the collection of the data, the processing of which, and the display of the output. It often answers the

question “What must I do so that I may be able to accomplish a certain task?” (Bronson, 2007).

Machine Learning

Machine learning is a branch of artificial intelligence that allows machines to simulate the way by which humans think and act. It is focused on the premise that computers are able to learn through the use of data, and allowing it to recognize patterns within them, allowing them to make decisions with little to no human input (“Machine Learning: What It Is and Why It Matters”, 2021). Learning and training the machine is similar to the way by which students are given multiple exams and practice sheets to be able to create a pattern in their understanding of the subject matter and be able to independently solve problems, based on the derived pattern (Kollur, 2018).

Machine Learning Model

A model is a physical representation of abstract concepts or is an imitative representation of another object (Merriam-Webster, 2021). A machine learning model is a representation of the result of training the machine to learn. This can be thought of as the “file” or “program” comprising both the data used as well as the algorithm used in order for the machine to learn (Brownlee, 2020).

System

A system is a collection of objects or components, interdependently working together to form a unit that performs a specific function or task. (“System”, 2021).

Support Vector Machine (SVM)

Support Vector Machine is a supervised machine learning algorithm commonly used in regression and classification. However, it is more commonly used in classifying data according to specific attributes (Bambrick, 2016). Data points are plotted across an n-dimensional space, and a classification is made through the separation of these data points with the use of a decision boundary. This is called a hyperplane, which essentially is a subspace, usually with *n-1*

dimensions which serves to separate the data across the space into the different classes (Cristianini & Shawe-Taylor, 2014).

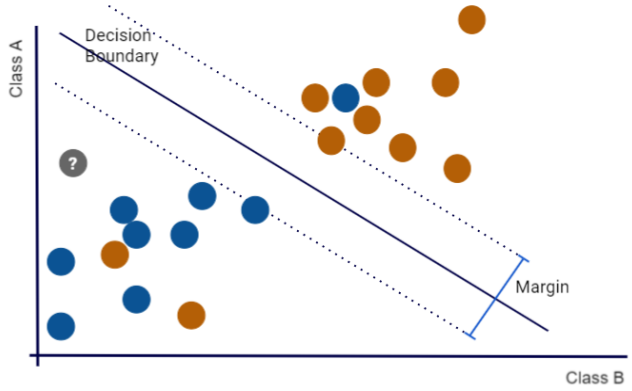


Figure 1: Diagram of a Support Vector Machine

Chen (2019) likens the concept of SVM to that of a road. A road has two sides, which are separated, similar to how cars, pedestrians, and buildings on the right side of the road are separated from those that are on the left side.

K - Nearest Neighbor (KNN)

The K-Nearest Neighbor algorithm is a supervised classification algorithm that classifies new data on the basis of the class of its k nearest neighbors in the process called voting. Depending on the value of k, the algorithm considers the k points nearest the new data point and gets a majority vote between the classes of its neighbor (Subramanian, 2019).

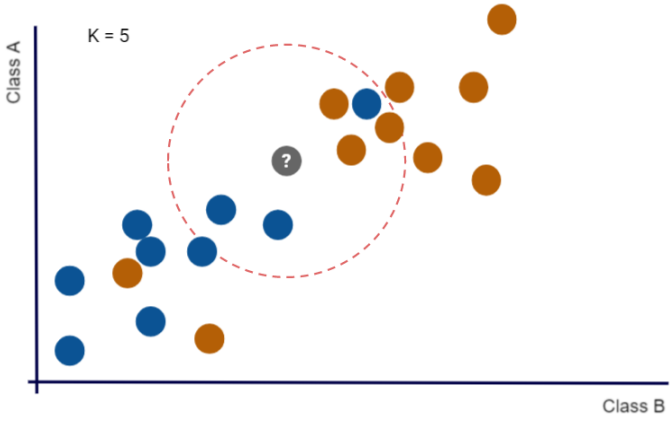


Figure 2: Diagram of k Nearest Neighbor

Decision Tree

Similar to the support vector machine, the decision tree is also a supervised learning algorithm, which can also be used in classification problems. In this algorithm, the machine makes decisions based on a set of decision rules or conditions, thereby, creating a branch of possible outcomes with every decision made (Chauhan, 2020).

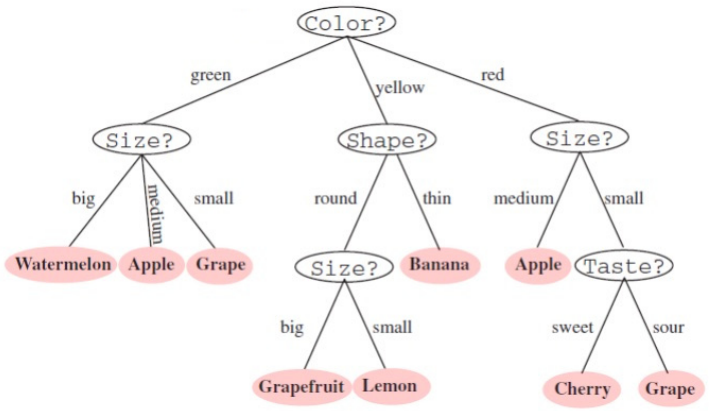


Figure 3: Diagram for Decision Tree

K-Fold Cross-Validation

Cross-validation is a statistical method commonly used in evaluating machine learning models for their accuracy. The k refers to the number of groups into which the data set is to be grouped into. The k could be a number that is representative of the data set and the model. Each group is then tested against the remaining subsets of data one at a time. The skill of the model is evaluated and is summarized, by finding the mean of the results of each test run (Brownlee, 2020).

CHAPTER 4
DESIGN AND METHODOLOGY

This chapter details the tools and procedures to be undertaken to aid the researchers in their efforts in solving computing problems. This includes the conceptual framework, analysis and design, and development model, as well as the schedule allocated in designing, developing, and testing the intended system, as well as the roles and tasks delegated to the research's proponents.

4.1 Research Environment and Respondents

Data collected for the research have been done through an online medium as the pandemic continues. The data used in the study are collected from an existing study done by Mir and Mittal (2020), which collected the information of persons who had thyroid problems, specifically hyperthyroidism and hypothyroidism, and persons with a normally functioning thyroid. The original data set contains 1,464 entries, with 21 features and one multi-class attribute. Of the 21 features, 18 of which are pathological factors while 3 are serological. However, in this study, the focus is placed on the utilization of the pathological factors with the objective of having a system that uses factors that are more visible and observable by a person, so that it becomes directly usable and accessible to people, especially to those deciding to seek medical help. In addition, the results of the study are verified with the help of an endocrinologist as well as a registered medical technician. Communication regarding updates and concerns intended for the medical professionals is done through the use of messenger, emails, and meetings, according to the availability of said expert.

4.2 Research Instrument or Sources of Data

The study uses an existing data set containing 22 total attributes and information on individuals with hyperthyroidism, hypothyroidism, and normally functioning thyroid. This data set is obtained upon the request of the proponents of this study from Mir and Mittal (2020) through electronic mail correspondence.

The image of the table below is taken from the study of Mir and Mittal (2020), which describes the data set used, showing the different attributes within the data set, along with their description and type. The data set consists of 18 pathological attributes and one multiclass attribute. The pathological attributes defining the data set have been noted to be symptoms observed when dealing with thyroid diseases.

DESCRIPTION OF THE PRIMARY DATASET

Attribute name	type	Description	Values	Value type
Age	Pathologic	Patient age in years	18-90	Numeric
Pregnant	Pathologic	Is patient pregnant	YES, NO, NA	Nominal
Trimester	Pathologic	Division of duration of pregnancy	1ST, 2ND, 3RD, NA	Nominal
Goitre	Pathologic	Swelling in front of neck	YES, NO	Nominal
Smoker	Pathologic	Does patient smoke	YES, NO	Nominal
Hair loss	Pathologic	Patient having hair fall problem	YES, NO	Nominal
Constipation	Pathologic	Difficulty in emptying bowels	YES, NO	Nominal
Diarrhoea	Pathologic	Watery bowel movements	YES, NO	Nominal
History	Pathologic	Family history	YES, NO	Nominal
Nervousness	Pathologic	State of being nervous	YES, NO	Nominal
Skin	Pathologic	State of the skin	NORMAL, ABNORMAL	Nominal
Menstrual bleeding	Pathologic	State of the menorrhagia	NORMAL, ABNORMAL, NA	Nominal
Feeling tired	Pathologic	Patient feels tired all time	YES, NO	Nominal
Sleepiness	Pathologic	Patients is having sound sleep or not	NORMAL, LESS, MORE	Nominal
Weight	Pathologic	State of the body weight	NORMAL, LOSS, GAIN	Nominal
Heart rate	Pathologic	Speed at which heart beats	NORMAL, LOW, HIGH	Nominal
Body temperature	Pathologic	Temperature of the body	NORMAL, LOW, HIGH	Nominal
T3	Serologic	Lab report for T3	2.7-5.27 pg/ml	Numeric
T4	Serologic	Lab report for T4	0.78-2.19 ng/dl	Numeric
TSH	Serologic	Lab report for TSH	0.465-4.68 u/ml	Numeric
Class		Diagnosis of disease	NORMAL, HYPER, HYPO	

In addition, the image also shows the description of each of the attributes along with their expected values, which are of nominal and numeric types. Once again note that the study will only be utilizing the first 18 attributes, which are of pathologic type as enumerated in the table.

4.3 Research Procedure

4.3.1 Gathering of Data

The general objective of the thesis is to be able to provide a means of determining an individual's thyroid state based on physical manifestations. The data set used is the same data set used from Mir and Mittal's study on hybrid ML techniques, originally obtained as medical records from the Sawai Man Singh (SMS) hospital. Data was originally gathered through a pre-designed questionnaire, which has also been verified by a medical expert.

4.3.2 Treatment of Data

The data were initially stored and organized as a CSV file. Most of its entries, especially the pathological features, are nominal in nature. These nominal-type entries were then recoded into a numeric equivalent through the use of IBM SPSS Statistics 25. Through the use of Google Colab along with a variety of Python libraries relevant to the algorithm used (e.g. Scikit-Learn, NumPy, Pandas, etc., the data was pre-processed, so that features of the pathologic type remained and features of the serologic type as well as duplicated rows were dropped. Rows with null values were also dealt with accordingly, and the data set is split so that a training set and a testing set were obtained.

4.4 Conceptual Framework

Thy-Sys is a system that serves as an initial evaluation of the wellness of one's thyroid. Thyroid diseases come second as one of the health concerns people go to endocrinologists for. Hence, the system attempts to determine the user's thyroid wellness, based on their responses to questions, related to observable characteristics of the more common thyroid diseases, such as hypothyroidism and hyperthyroidism. In addition, should a thyroid disease be detected, a medical checkup is advised. The assessment is done through the use of the SVM classification algorithm on the acquired data set. Hence, the

application is now aimed to become a practical use of the systems that use machine learning in thyroid prediction.

Figure 4 illustrates the flow of a diagnostic process, observed by doctors in the event of a patient visit, particularly for patients who are having their first consultation.

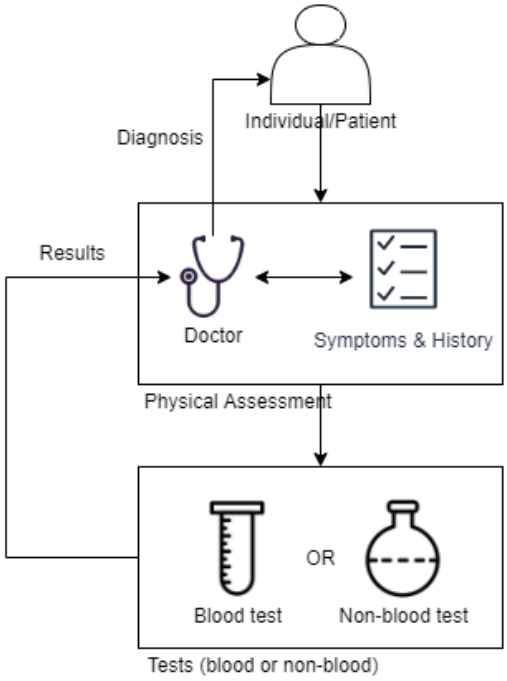


Figure 4: Diagnostic Process

The individual visits the doctor's clinic for a consultation about their concerns. The doctor performs a physical assessment - a thorough review and inspection of the individual's symptoms, family, and medical history, which comprise the pathological factors considered in the study. The said assessment is done to determine the likely cause of the person's medical condition, and the appropriate test given to the patient.

Figure 5 shows the system's main purpose, which is to provide an alternative preliminary evaluation for thyroid wellness.

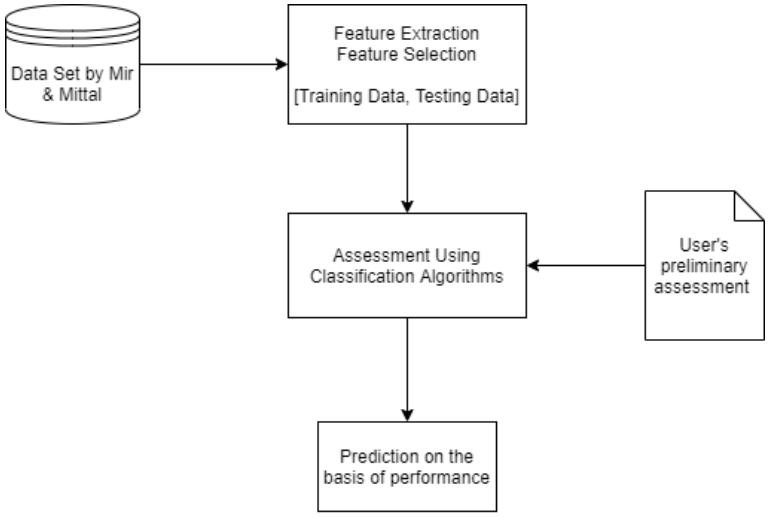


Figure 5: Thy-Sys Conceptual Framework

From the data set, the features used in the study (the pathologic attributes) are selected, and the instances within the data set are used in training and testing the learner algorithm. The resulting model is validated on the basis of its accuracy in classifying the data as that of hyperthyroidism, hypothyroidism, and normal thyroid. From there the system can be interfaced by the user by answering questions related to the selected features used within the model. Responses are passed to the model and produce the results of the evaluation of the thyroid's condition (with disease or free of disease). A consultation with a medical professional may also be encouraged so that individuals may seek out further testing and diagnosis.

4.5 Analysis and Design

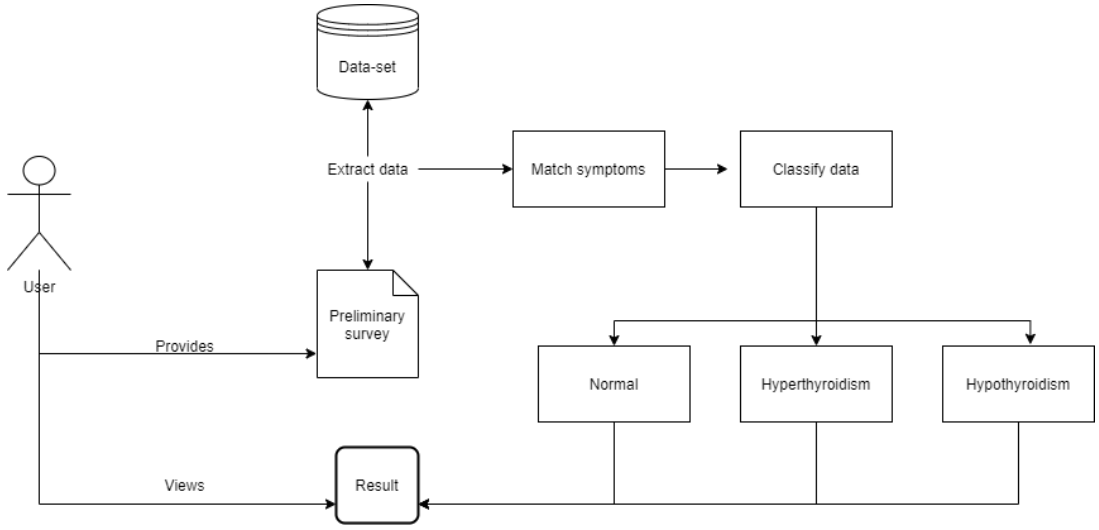


Figure 6: Use-Case Diagram

Figure 6 provides a general assessment on how the users are to utilize the system created by the researchers. In a fashion similar to a preliminary survey, the users are to answer questions regarding symptoms of thyroid diseases. The responses are obtained and passed through a model and the results of the assessment are derived through the model that was previously tested and trained. The results may also be viewed by the users.

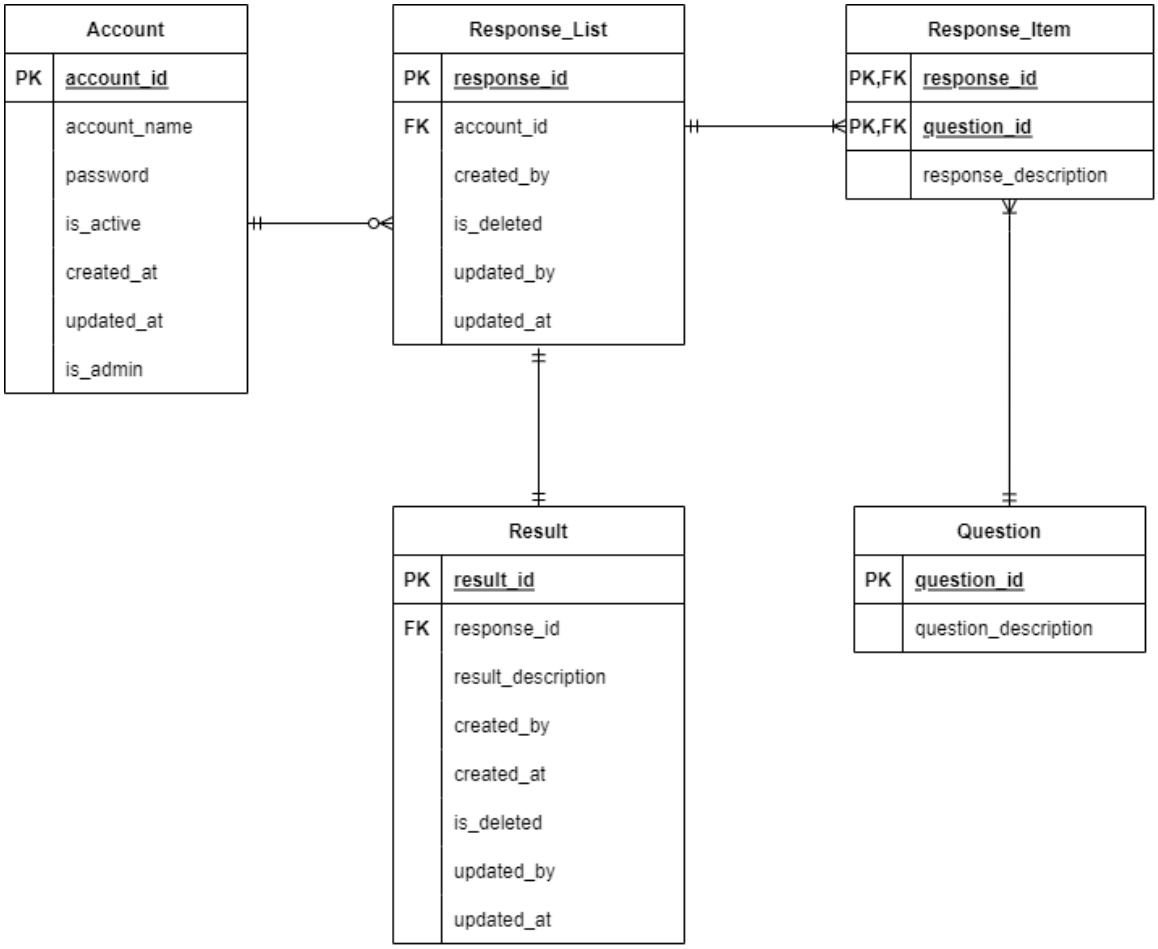


Figure 7: Thy-Sys Entity Relationship Diagram

Figure 7 shows the relationship among entities present and implemented within the system. The diagram shows that the person using the system has an account. Questions regarding the guided assessment are displayed and then answered by the user. In addition, the responses to the questions, as well as the produced results are stored in the database, so that they are visible and can be viewed at any time by the individual utilizing the system.

4.6 Development Model

The researchers have chosen to use the Agile Framework known as **Kanban**. Kanban acts like a scheduling system that allows developers to envision workflow in the hopes of identifying bottlenecks or backlogs and reducing wait time (Mendix Tech, 2021). This is done with the use of a Kanban board, which works similarly to task boards, where the written tasks (Kanban

cards) are transferred from one column to another, depending upon their status. The use of the Kanban board allows for the visualization of which tasks, as well as the members of the team, are assigned to the specific task. This keeps members of the team up-to-date with what has been done and what else needs to be done (Atlassian, 2021).

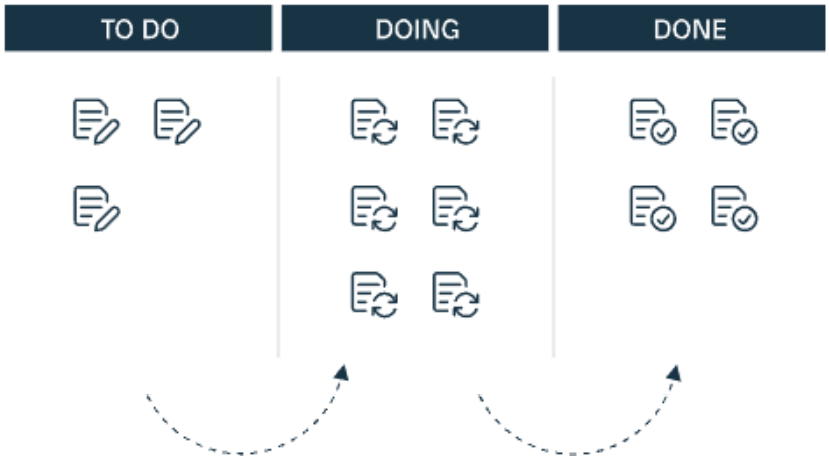


Figure 8: Visual Representation of Kanban framework

Most Kanban boards are classified according to “to-do”, “doing”, or “done”. However, large projects and teams may require additional time to further specify the stages of the development of the project until they are completed. There is no specific number of columns to be used, but the board should be effective in allowing task visualization as well as organization.

The **to-do** column of the board pertains to the planning stage, as well as the modularization of the large tasks into more manageable tasks.

On the other hand, the **doing** column contains the tasks that are works in progress.

Furthermore, the **done** column exhibits the tasks that have already been completed. Members of the team are able to monitor tasks that have already been completed and by whom. In this case, apart from thesis revision, tasks like considering the best algorithm to choose and the software application to use are

also included. This includes the creation of the model of the algorithm, the training and testing, and the verification and validation of the results.

4.7 Development Approaches

The development of Thy-Sys utilized the bottom-up development approach. This means that the study and the system come as a result of progress made by using and combining different elements.

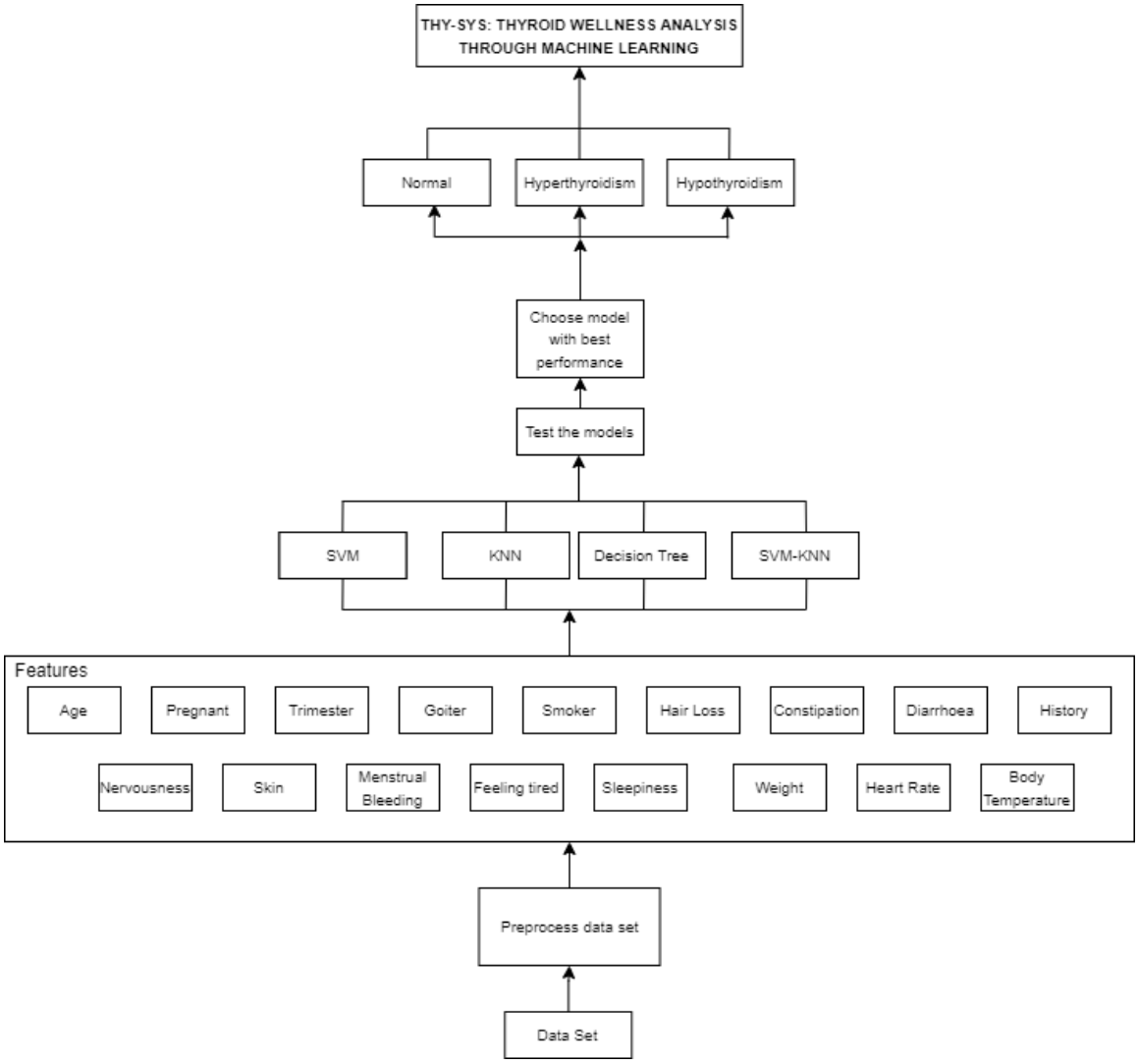


Figure 9: Bottom-Up Approach of Thy-Sys

Figure 9 shows the approach taken, whereby the system and model developed dependent upon the data collected. The data is then preprocessed and the relevant attributes to be used are determined before the data is then

grouped to either be the training or testing set. Training and testing are performed on the different chosen algorithms. Once classifications were accurate and were found reliable, the researchers chose one of the models to be employed in the system on the basis of its performance. Afterward, the system is complete, showing the entirety of the working elements, from the data set used to the processes and algorithm employed.

4.8 Software Development Tools

Numerous tools, software, and library packages are used in the execution and development of the intended system of this study. The software used with their appropriate versions, as well as their use is enumerated in Table 1 below.

Table 1

Software Development Tools

Software	Version	Use
Google Chrome	83.0.4103.122	Software used to access sites and use Google Colab
Visual Studio Code	1.56.0	A code editor used in creating systems and software
Google Colab		A free and public, interactive, and collaborative environment intended for writing code used in data science
Github	2.28.0	A code-hosting platform intended for collaboration in software and system development
Jira	8.13	A project management software that is used in organizing and tracking tasks within a team
IBM SPSS Statistics 25	25.0.0.0	A software, that stores and displays data through a spreadsheet and is used for doing statistical analysis
MySQL	8.0.1	A relational database management

		system used in the storage of a wide range of data
Sci-kit learn	0.24.1	A Python package for data mining
Chefboost	0.0.13	A Python package to create decision trees
NumPy	1.20.2	A Python package used when handling arrays
Pandas	1.2.4	A Python package used in data analysis and handling different file formats
PyQT5	5.15.4	A Python package that is used in providing a graphical user interface.

4.9 Project Management

This section discusses the schedule and timeline, responsibilities, budget, and cost management of the team at the time of the development of the research project. Each subsection discusses its purpose as well as the reason for the decision made in the management of the project.

4.9.1 Schedule and Timeline

This subsection indicates the timeline observed and followed by the researchers in compliance with submission deadlines as well as incremental research deliverables. Table 2 shows the list of tasks, scheduled according to the different stages in accomplishing the research. Table 2 shows the activities and deliverables to be accomplished within the 2nd semester of the Academic Year 2020 - 2021 with the objective of a thesis proposal.

Table 2

Gantt Chart of Activities, Second Semester, A.Y. 2020 - 2021

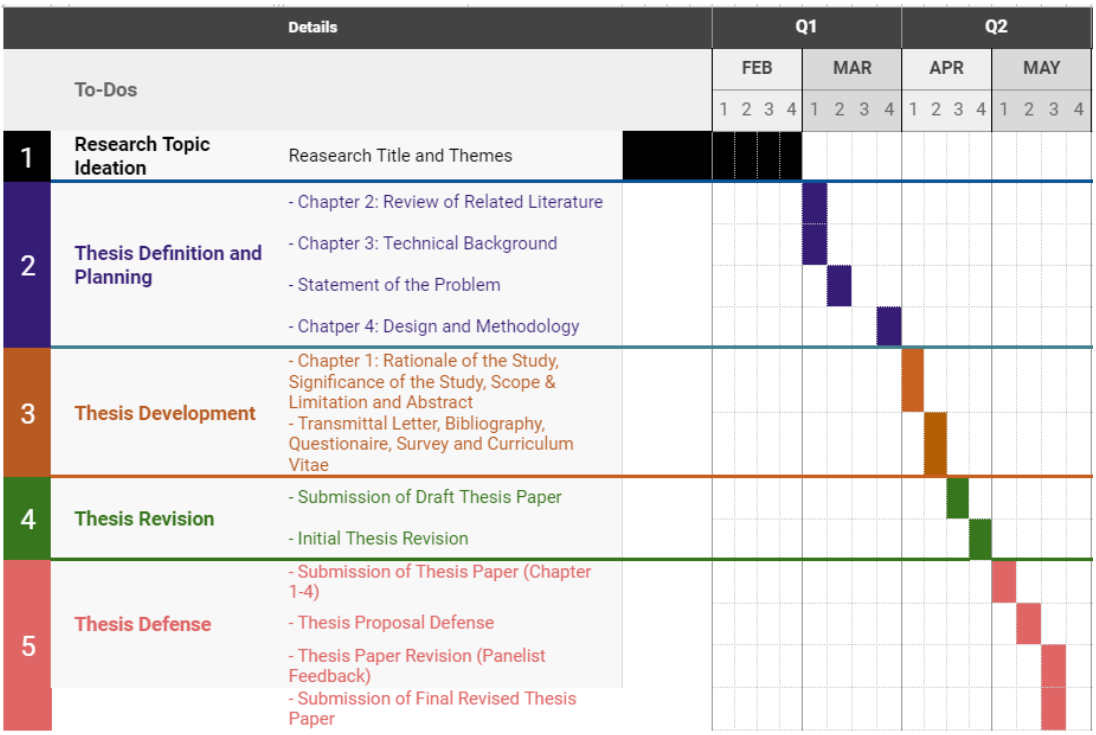
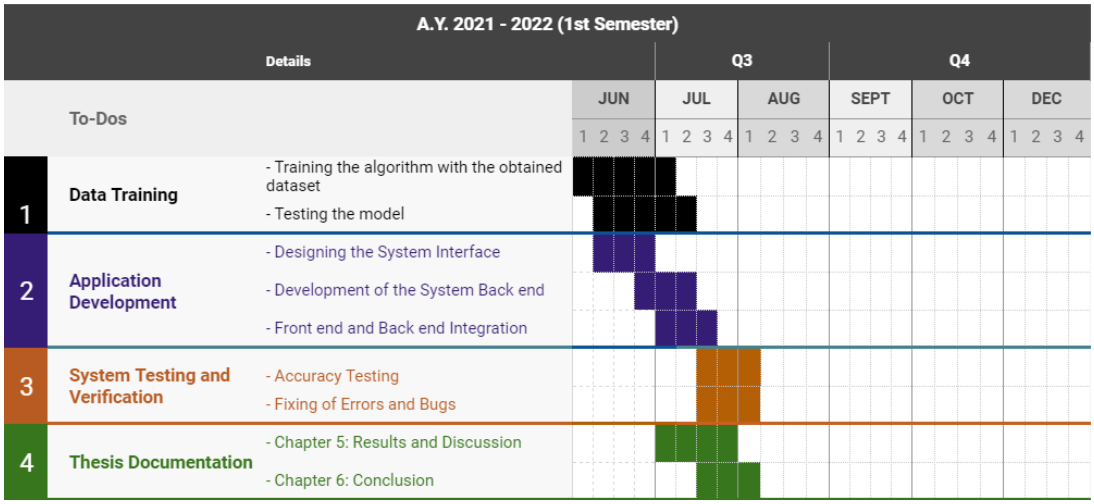


Table 3, on the other hand, shows the table of schedule, which dictates the flow of work to be observed during the second half of the completion of the thesis. Within the second half, the actual employment of the proposed system/algorithm commences - this includes the training of the algorithm as well as the testing, and verification, and validation of the accuracy of the obtained results.

Table 3

Gantt Chart of Activities, First Semester, A.Y. 2021 - 2022



4.9.2 Responsibilities

In the course of executing the planned tasks for this research, roles were assigned to each individual partaking in the said activity, so as to ensure that submission deadlines are met and deliverables are complied with.

Generally, the system is divided into two phases: the training phase and the testing phase. The training phase refers to the phase of supervising and coaching the algorithm into producing a correct and desired output. On the other hand, the testing phase involves the evaluation of the model's performance.

Below is a table, Table 4, which lists down the proponents and their respective roles and responsibilities in fulfilling the research objectives.

Table 4

Table of Roles and Responsibilities

Member	Roles	Assignment
Mary Bernadette Ferolin	Researcher and Back-end Developer	Collect the data to be used in the study
		Learn the basics concepts of Support Vector Machines, and KNN and how these are implemented
		Train the models using the data sets, and test them, afterward.
		Do the backend of the system and integrate the model to be used.
Ismael Francisco	Researcher and Front-end Developer	Learn the basic concepts of the Decision tree and how it is implemented
		Pre-process the data to be used in the testing and training of the model
		Train the model using the data sets, and test the model, afterward.
		Evaluate the performance of the model on the basis of its accuracy, and develop the system interface

4.9.3 Budget and Cost Management

In addition to the role assignment of each member, the total expenses in conducting the research are also taken into consideration, to determine the cost of conducting the study.

Table 5 is a table of expenses, cataloging the items and gadgets used within the span of the thesis conduction duration as well as their corresponding prices. Should future improvements and studies on this subject be conducted, the table can be referred to for the approximate cost.

Table 5

Table of Expenses

Items	Cost
Laptop (Acer Aspire E5-575G & Acer Aspire E5-576G)	68,000.00
Conference Fee (Conference Registration Fee)	25,000.00
Miscellaneous	10,000.00
Total	**103,000.00**

4.10 Verification, Validation, and Testing

When the main objective of the study was accomplished, it was then validated and verified to ensure the quality of the study. This includes accuracy and metric scores (e.g. precision, recall, F1) of the results based on the training and testing of the data set, as well as the means by which the training and testing is done. This subsection of the chapter discusses the methods employed in the validation and verification of the system.

Experts from the medical field were invited to validate the accuracy of the results obtained by the application. This pertains to whether the questions within the questionnaire were appropriately crafted, and if the system was able to accurately classify if the combination of answers to the questions is more likely to be one kind of thyroid disease or the other or no disease at all. Lastly, the medical experts gave an insight into the appropriateness of the message displayed on the results screen of the application.

The performance of the algorithm on the data set was tested for their reliability through the use of 10-fold cross-validation whereby the data set was divided into 10 different subsets, and with each subset becoming a testing set, and tested against the remaining subsets. The accuracy, the recall, precision, and f1 scores of the performance of each test in terms of its ability to classify were then observed, and their mean was taken.

In addition, a confusion matrix was employed in order to determine the number of correctly and incorrectly classified instances during the testing phase of the chosen model. Having the confusion matrix not only allowed for a visualization of the accuracy in terms of the actual data points but also gave an insight into the other metric scores and how the model would fare in the real world. This is especially important since the system would be dealing with real-life data in the medical field.

CHAPTER 5
RESULT AND ANALYSIS

This chapter illustrates the outcomes of the different processes taken in order to achieve the goals set forth by the researchers at the beginning of this study. Furthermore, it further expounds on the different methodologies and environments used in obtaining such results.

5.1 Pathological Factors Verification

The data set used in the study contains a total of 1,464 entries. Each entry has twenty-two (22) attributes with eighteen (18) of them being pathological: age, gender, pregnancy, trimester, the presence of goiter, smoking habits, hair loss, constipation, diarrhea, family history, nervousness, skin condition, menstrual bleeding, feeling tired or fatigued, sleepiness, weight loss or gain, and body temperature. These pathological factors, in various medical researches, were found to be some of the very common conditions indicative of or contributing to the likelihood of having thyroid disease. As these are the factors considered in the study, they have also been verified by medical experts before being used. These 18 pathological factors were confirmed by Dr. Leyco, an internal medicine endocrinologist, in an interview, to be some of the factors considered when giving the patient a physical examination during a consultation (Appendix B, Transcript of Interview with Dr. Leyco, IM, Endocrinologist). During the interview, Dr. Leyco also emphasizes how menstrual bleeding, as one of the pathological factors, refers to the duration of the cycle (longer or shorter durations) rather than the volume of blood produced during a cycle. Other pathological factors and symptoms, reported by patients, were also introduced such as difficulty in breathing (dyspnea), and bulging of the eyes (proptosis or exophthalmos).

Such verification of the factors is also consistent with the responses given by Ms. Junie Caber (Appendix B, Transcript of Interview with Ms. Junjie Caber, RMT, MPH), who also confirmed in an interview how the different factors enumerated are equally considered during a physical assessment. The patient's response to these factors now becomes the determinant of the likelihood of

actually having the disease or not. Both experts note, however, that there can be times where patients exhibit several of these pathological factors but end up with negative results after taking (a series of) tests, which is why though the symptoms and other pathological factors may be indicative of the disease, tests are done in order to confirm these suspicions and worries.

5.2 Model Selection

Various studies have shown the possibility of predicting the presence of thyroid disease in a person based on a number of factors. Most of these studies give much of their focus to serological factors like levels of the hormones TSH, T3, and T4 present in one's blood. However, because of the pandemic, direct access to medical help has become very limited. Hence, the authors of this study committed to having a system that actualizes these studies, but with the use of pathological factors, which are more visible and observable by a person, so that it becomes usable and accessible to people, especially to those deciding to seek medical help. The system, then, aids the users on what factors and conditions are to be observed so that the self-assessment does not become ambiguous.

The developed system utilizes an ensemble machine learning model in assessing the user for the presence or absence of thyroid problems. This is based on their responses to questions pertaining to pathological factors commonly observed in said problem. During the training and testing phase of the development, three algorithms, namely SVM, KNN, and Decision Tree were initially considered. In addition, another model, which uses an ensemble technique called Stacking, was also considered. This new model is an aggregate of the based models, which has combined the capabilities of both trained SVM and KNN as learners. The data set, initially containing 1,464 entries, now has 1,106 rows with 578 instances of "hyperthyroidism", 398 for "hypothyroidism", and 130 for "normal" thyroid condition. In this case, an imbalance of data between classes can be observed. Unfortunately, the performance of some of the classification algorithms is influenced by a class imbalance – SVM, KNN, and Decision Trees are no exceptions to this behavior. To remedy this, Synthetic

Minority Oversampling Technique (SMOTE) was employed to balance the number of data set samples.

Table 6 shows the summary of the results of the different models according to their accuracy.

Table 6

Accuracy of the Machine Learning Models

ML Model	**With SMOTE?**	**Accuracy (%)**
Support Vector Machine (SVM)	No	97.18
	Yes	97.74
K Nearest Neighbor (KNN)	No	91.53
	Yes	94.93
Decision Tree (CHAID)	No	96.69
	Yes	97.29
Stack (SVM-KNN)	No	97.30
	Yes	99.50

The SVM model shows generally good accuracy of 97.18% with the imbalanced data set and an improvement of 97.74% with a more balanced training set. An SVM classifier is generally known to perform well and is one of the machine learning algorithms commonly used in classification and prediction. In addition, KNN, another commonly used classifier, classifies an object on the basis of the class of its k neighbors. The developed KNN model showed an accuracy of 91.53% and 94.93% when trained using an imbalanced and balanced data set, respectively. The decision tree model also tended to garner a relatively better accuracy when oversampling is observed. However, based on the accuracy result, it is observable that an ensemble of both SVM and KNN garnered the highest possible accuracy of 99.55% when trained under a

relatively balanced data set, improving the accuracy from the performance of the two base models.

In addition to the accuracy, through the use of a 10-fold cross-validation method, the researchers were also able to obtain an average performance of the models through other metric scores (precision, recall, and F1). Table 7 shows the different metric scores obtained from each model. All of the developed models showed generally high scores for precision, recall, and F1. However, once again, the stacked model shows the highest scores with 98.75% for precision and 98.61% for both recall and F1.

Table 7

Metric Scores of the Machine Learning Models

ML Model	**Metric Scores (%)**		
	Precision	***Recall***	***F1***
SVM	95.63	97.38	96.12
KNN	92.50	96.39	93.20
Decision Tree (CHAID)	97.66	98.00	98.30
Stack (SVM-KNN)	98.75	98.61	98.61

Moreover, a confusion matrix also allows for a visualization of the performance of the model by revealing the number of correctly as well as incorrectly classified instances done by the model. The confusion matrix for the stacked model is shown in figure 10.

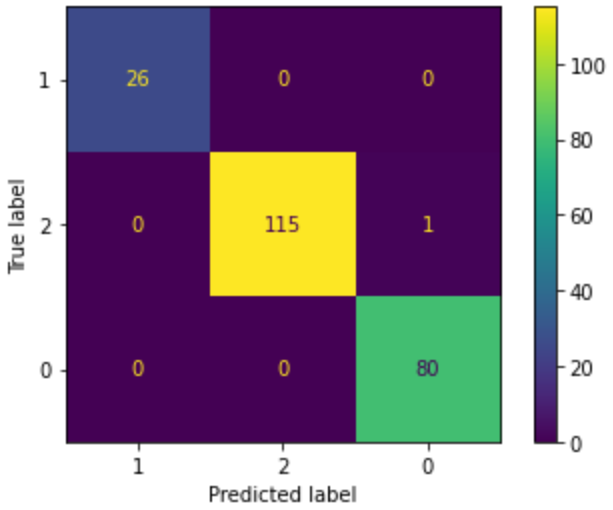


Figure 10: Confusion Matrix for SVM-KNN Model

The matrix shows that among the total 222 objects from the testing set, only one object has been misclassified. This particular object was placed under the class called “hypothyroidism” (labeled 0 in the figure) when it was meant to be classified as “hyperthyroidism” (labeled 2 in the figure). Thus, the matrix illustrates how each of the data is classified and offers a visualization of what a 99.55% accuracy looks like in terms of the actual objects within the testing set. This shows that the model not only does a good job of classifying but is also reliable in its performance of doing so. Furthermore, the consideration of the different metric scores of the model is crucial since the model is intended to be used in the real world and must be fed with realistic data. This becomes especially more important since it is dealing with a person’s health. By evaluating the models through their accuracy, precision, recall, and F1 scores, the SVM-KNN model was chosen to be employed in the development of the system.

5.3 System Implementation

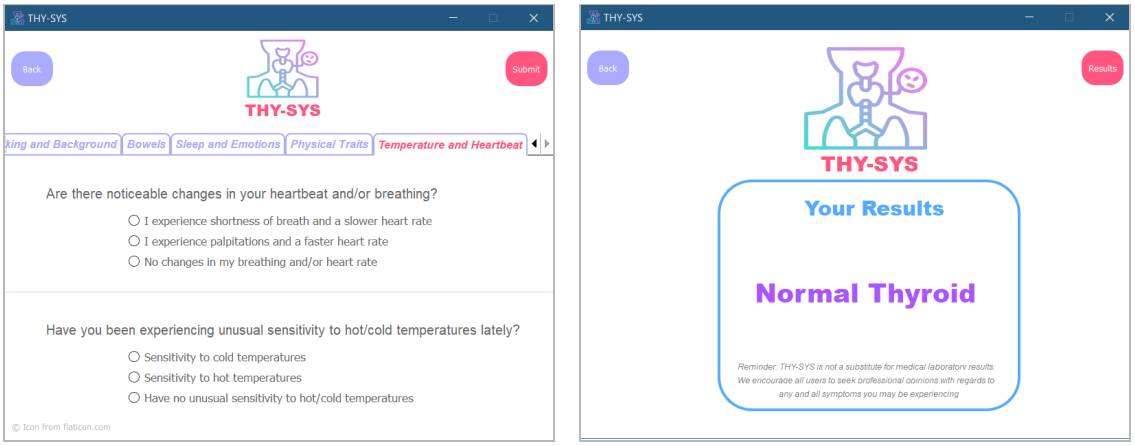
The system is a desktop application developed using PyQT5, a Python toolkit that allowed the researchers to model the interface according to the workflow described in section 4.5. Figure11(a) shows the interface first encountered by the user every time the application is opened. Initially, the user registers their username and password and is led to the menu, which allows

them to log out, or proceed and take the assessment or view their previous results, as shown in figure 11(b).

(a) Landing Page (b) Menu Page

Figure 11: System Interface (Landing, Registration, and Login)

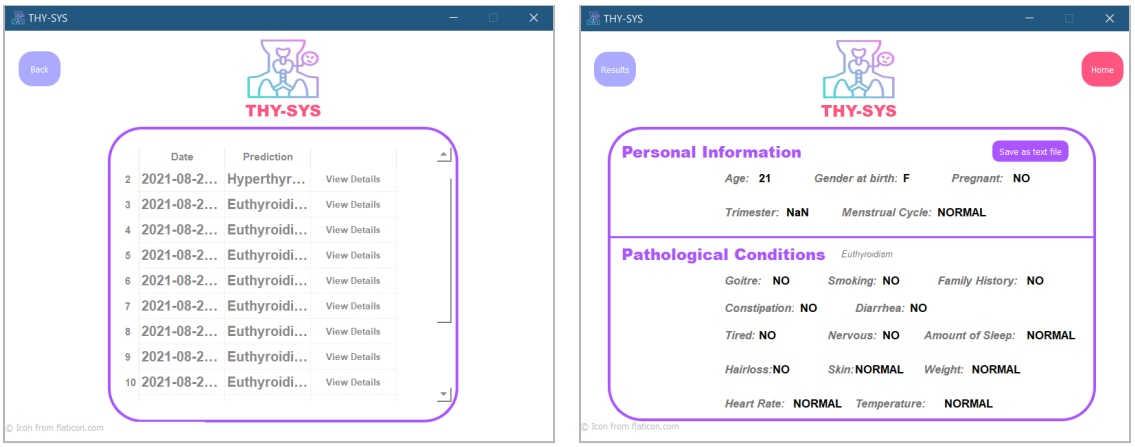
The developed system aims to be able to determine if certain conditions experienced by an individual, along with other pathological factors, belong to someone who is experiencing an excess, a lack, or sufficient amounts of thyroid hormones. For this to happen, a user should answer a series of questions pertaining to their age, gender, and other symptoms (e.g. constipation, heat intolerance, fatigue, etc.) related to the thyroid diseases focused in this study. This process is likened to that of the activities done during initial clinical check-ups, which focuses on getting to know what the patient is feeling, the reason for the patient's visit, as well as the duration and the possible factors contributing to the visit. Figure 12(a) shows how the system does this by displaying questions on a particular symptom (e.g. heart rate, intolerance to certain temperatures, etc.), and enumerating a choice of responses to the question, resembling the different symptoms manifested and observed by the user taking the assessment.



(a) Assessment Questionnaire (b) Result

Figure 12: System Interface (Assessment Process)

The array of responses provided by the user is then sent to the stacked SVM-KNN model. The model now becomes responsible for the prediction of the presence or the absence of thyroid disease and returns a prediction. The result, shown after the user's submission, is the system's prediction based on the received array of responses, as in figure 12(b).



(a) List of Results (b) Recorded Responses

Figure 13: System Interface (Assessment Results)

It is worth noting that the system is not intended to substitute clinical diagnosis, but rather support clinical assessment, and thus encourages individuals to seek medical help especially when necessary, potentially serving

as a preliminary evaluation in the new normal mode of doing activities. Thus, the system also stores the current result and responses, as well as allows the user to view a list of their previous results, and the symptoms they have claimed to have observed, shown in figure 13. This is for the purpose that the user will not only be able to monitor their well-being, but also allow their healthcare provider/physician to have an idea of who their patient is and how they are, and aid them in the process of checking up and officially diagnosing the patient.

CHAPTER 6
CONCLUSION AND RECOMMENDATION

The thyroid, though small, is one of the most important organs of the body responsible for maintaining the body's overall homeostasis and regulating the body's responses to various stimuli. Monitoring its state is vital and remedying any problems that could be experienced is crucial before it could potentially get worse. The study resulted in a system that allowed a computer application to determine the state of one's thyroid by examining the pathological factors which a person has observed. Prior to its development, three base models, SVM, KNN, and Decision Tree were considered, and trained, and tested under different data conditions. With a balanced data set obtained through an oversampling method, SVM garnered the highest accuracy among the three base models, with 97.74% accuracy. In addition, a stacked model was also developed by creating an ensemble of two base learners, SVM and KNN. This resulted in a 99.55% accuracy, improving significantly than when only either of the models was tested, and was, hence, used as the machine learning model behind the system.

The resulting system is not a replacement of official diagnosis, but support for medical professionals in the process of diagnosing. Only laboratory tests can determine the definitive absence or presence of the disease, and while there are instances where the symptoms and diagnosis of the disease coincide with one another, it is also possible to test negative for the disease even with the manifestation of some of the characteristics described. Hence, the system serves as an initial assessment as well as a motivator to seek a medical professional's help, especially during this pandemic. A guided self-assessment makes individuals aware of the factors and conditions that contribute to the likelihood of contracting the disease and allows them to be conscious of its manifestations through the symptoms. The factors and symptoms used in the system have been verified by medical experts to be the things taken note of during consultations, particularly concerning thyroid. Moreover, it lessens the risk of individuals having to leave their homes to directly visit medical establishments and wait in the midst

of a pandemic, while strengthening the justification to have a medical checkup most especially when the need arises.

For future studies, the authors recommend the collection and use of additional data set for training and testing to improve the model performance leading to more robust results, especially data coming from people in the Philippines. Furthermore, other pathological factors related to thyroid diseases (e.g. difficulty in breathing, bulging of eyes, exposure to radiation, iodine intake, etc.) may also be considered features, to try and make predictions of thyroid diseases, based on such factors, more accurate.

GLOSSARY

Accuracy is the ratio between items correctly classified and the total number of items. For example, if there were a total of 100 items and 68 correctly classified items, then the ratio between those two, 0.68 (68%) is the accuracy.

Decision Tree is a Tree-like structure that models probable outcomes. Each branch represents a decision-making step that leads to a favorable result. This means that it presents algorithms with a conditional control statement.

K Nearest Neighbor is a supervised classification algorithm that classifies new data on the basis of the class of its k nearest neighbors in the process called voting. The majority of the "votes" defines the class of the new data.

Machine Learning is a branch of artificial intelligence that allows machines to simulate the way by which humans think and act.

Model is a physical representation of abstract concepts or is an imitative representation of another object. In machine learning, a model is a representation of what the machine has learned.

Pathological Factors are factors that can indicate the presence of a disease and may contribute to the likelihood of contracting the disease.

Support Vector Machine is a supervised machine learning algorithm used in the classification of data in an n-dimensional space. The classification is done on the basis of different characteristics and by dividing the classes using a decision boundary.

System is a collection of objects or components, interdependently working together to form a unit that performs a specific function or task.

Testing is the process of introducing a new set of data in order for the machine learning model to do its task to see its performance, based on what it has learned with the older data set.

Thyroid Wellness is the overall state of the thyroid organ. This refers to whether the thyroid is experiencing problems or not.

Training is the process of feeding sets of data to a model in order for it to find and learn patterns relevant to doing its specific task.

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APPENDICES

Appendix A
Transmittal Letter

UNIVERSITY of SAN CARLOS
SCIENTIA • VIRTUS • DEVOTIO

DCISM
DEPARTMENT OF COMPUTER, INFORMATION SCIENCES AND MATHEMATICS

April 21, 2021

Theresa G. Leyco, M.D.
Endocrinologist

Dear Dr. Leyco,

Greetings!

May we request from you permission for us to consult with you regarding our thesis entitled "THY-SYS: THYROID WELLNESS ANALYSIS THROUGH MACHINE LEARNING ". The above project is a requirement for the completion of Computer Science Thesis 1 in the Department of Computer, Information Sciences, and Mathematics of the University of San Carlos. We believe that the result of the study would be useful and helpful in the betterment of the community particularly in this new normal. We would be more than happy to provide any clarifications with regards to any inquiries with regards to this thesis topic.

We look forward to your response. Thank you.

Respectfully yours,

Ismael R. Francisco
CS Thesis 1 Student

Mary Bernadette Ferolin
CS Thesis 1 Student

Endorsed by:

Christine F. Pena
Thesis Adviser

Approved by:

Theresa G. Leyco, M.D.
Endocrinologist

Appendix B

Transcript of Interview

Transcript of Interview with Dr. Leyco, IM, Endocrinologist

***Date of Meeting*:** May 18, 2021 (Tuesday)

Venue: Messenger

Meeting attendees: Mary Bernadette J. Ferolin (researcher/interviewer) and Dr. Theresa G. Leyco (Internal Medicine Endocrinologist / Interviewee)

***Start Time*:** 6:18 p.m.

***End Time*:** 7:20 p.m.

-- Start of Interview --

Bernadette: Good evening Dr. Leyco. I hope I am not disturbing you too much at this moment. I would like to expound more regarding the thesis which has been proposed by my partner and me. It's a Thyroid Wellness Analysis system that allows a person to be guided on assessing the condition of their thyroid. So the way this is done is by allowing the person to answer a series of questions regarding manifestations of either hyperthyroidism or hypothyroidism. If the system believes that there is a high chance of thyroid disease, it informs the person and encourages them to go see a doctor. But if it's alright with you, I have a few more questions to ask regarding the doctor's side of the processes taken in determining and diagnosing the thyroid disease?

Dr. Leyco: Ok sige

Bernadette: Thank you. I would like to ask untah regarding the clinical process. Like what happens when a patient goes to see you and then tells you about what they're feeling.

Dr. Leyco: After asking the patient about her symptoms, getting her medical, family, and personal/social history, we do a physical examination. We check the vital signs (bp, heart rate, respiratory rate, temp), measure weight and height, examine each organ system, then we discuss the diagnosis or at least the impression at that point and the diagnostic and therapeutic plans

Bernadette: After that, necessary bah na proceed ug lab tests? Is it necessary?

Dr. Leyco: Yes. Especially for thyroid disorders cause the symptoms can be nonspecific mn gud. Notice that the symptoms of hyperthyroidism overlap with symptoms of anxiety disorder? That's the reason why we need lab tests to confirm the diagnosis and also, it will serve as our baseline to guide us on how to adjust the meds later on

Bernadette: Oh... I see. So based on the symptoms and family history and other factors, it is possible for you as doctors to be suspicious of some of the diseases, but will need further testing for confirmation?

Dr. Leyco: Yes. Although the practice of medicine differs in the rural setting I think ha. I'm not quite sure. I imagine na they treat nalang right away even without labs because of so many limitations. That's why dili ideal ang management of diseases in the rural setting

Bernadette: Oh I see. Kay if that's the case kay need sd jd diay ug attention ang medical system sa rural areas.

Dr. Leyco: Yes. So many deficiencies diha sa ilaha. I'm sure you're aware of that. Mao na usually ma-feature sa mga documentaries hehe.

Bernadette: Yes doc. Mao sad nah actually naka push for further thyroid studies. Pero should they need tests, what are some of the tests na idiscuss ninyo with your patients bah?

Dr. Leyco: Sa urban setting, you mean? For suspected thyroid disorders, we ask them to do the following blood tests: TSH and FT4. Then ultrasound of the thyroid sometimes. Actually, we have an impression naman just based on history and PE. Notice na in some cases (cough and colds during pre-covid times, or asthma), we don't ask for labs na. We treat na direcho. But it's a different thing when it comes to thyroid disorders.

Bernadette: Ahh in general, doc.. for patients who usually come to you?

Dr. Leyco: For thyroid disorders gihapon right? That's what we ask for. I cannot answer for the rural setting coz I don't know how they manage the cases there.

Bernadette: Yes doc. I understand. Thank you for clarifying that. Last natong sturya, you mentioned na lahi ang testing and consultation fee. Do you have any insight na what if mu come out negative ang tests sa person? Do you think it is wasteful bah? Or should it be seen as something positive or negative?

Dr. Leyco: I don't think it's wasteful mn. Here's a real example of some patients I see… [A] Young lady comes to see me in [the] clinic because she thinks she has hyperthyroidism. She complains of palpitations and difficulty sleeping. She admits na she has been stressed lately sa school work nya. But her mother has hyperthyroidism. That's why she's worried na she might have hyperthyroidism too. Lab tests turn out to be normal. I reassure her that she has no thyroid disorder. The patient is relieved and realizes that it's just her stress that's causing the palpitations and insomnia.

Bernadette: Oh actually... relevant jud kaayo nah example. So, encouraged lang jud gihapon mu pa check if naay something na feel out of the ordinary.

Dr. Leyco: Yes. 'Cause some people think na what they're feeling is because of certain stressors/events in their life lang when in fact they really have a disorder diay. And it can also go the other way around.

Bernadette: Yes. I agree. Although naa jud gihapon uban hadlok muadto ug doctors. Pero as a doctor, in the new normal, how many patients do you see in a day? and how often do you get appointments?

Dr. Leyco: We limit naman kay pra dili magcrowd sa clinic. So in my case, I see an average of 10 patients a day. But my clinic is 2 days per week lang.

Bernadette: May I ask lang doc, if this system were implemented, would you find it helpful to have an idea daan of what the patient is feeling and then be able to dive deeper based on their responses?

Dr. Leyco: Yes. So the px comes in with an already filled-up checklist? Yes, that will be helpful. Although the doctor will double-check jd and go through each item with the px, even the unchecked ones. But yes, it makes the consultation process a bit faster.

Bernadette: Yes doc.. that's sort of the aim sad. Cause we were thinking about the process of having to go to the clinics directly during the pandemic. I think mag pa appointment mn jud for the most part. So mao nah nga if they feel something, ma encouraged sila to see a doctor. Last clarification lang doc.. are these some of the things you would look out for when having a checkup?

At this point, the table of pathological factors is shown

Dr. Leyco: Yes. That's for hyperthyroidism right? That's very good. Regarding menses, it's more of the cycle or duration that is affected and not the volume. Like kasagaran layagan or shortened ang mens rather than kusog kaayo ang flow. Also, you can add breathing. They sometimes complain of difficulty in breathing (dyspnea). And some notice that their eye(s) bulge (proptosis or exophthalmos).

Bernadette: Ay actually.. I wanted to ask sd. Do patients normally go directly to endocrinologists for patients for first-time consultation? Or do they go through a general medicine doctor first before being referred to a specialist?

Dr. Leyco: Generally, it's supposed to be GP or internist 1st (general practitioner) then if it needs subspecialty expertise, GP/internist refers to a subspecialist, in this case, an endocrinologist. But in reality, patients (I mean paying patients, not those with insurance like intellicare, maxicare, etc., or those charity pxs like the ones who go to gov't hospitals) may go and see us directly.

Bernadette: Ahh I see... Kay I usually understood it from the general case nga mag-una usually sa general practitioners. Thank you so much doc, you have clarified most of my queries today. It has been helpful. Thank you for your time.

Dr. Leyco: Ok sige. Good luck to you guys.

Bernadette: I would like to ask untah if okay rbah nimo i-include namo imo responses in our thesis document? That way we have reference to your expertise?

Dr. Leyco: No problem.

Bernadette: Thank you so much doc!! It means a lot.

-- End of Interview --

End Time: 7:20 p.m.

Transcript of Interview with Ms. Junjie Caber, RMT, MPH

***Date of Meeting*:** May 14, 2021 (Friday)

Venue: Messenger Video Call (from Brgy. Bacayan to Nuclear Medicine Clinic, Perpetual Succour)

Meeting attendees: Ismael R. Francisco (researcher/interviewer) and Miss Junjie Caber(Chief Nuclear Medicine Technologist PSH / Interviewee)

***Start Time*:** 10:30 a.m.

***End Time*:** 11:30 a.m.

-- Start of Interview --

Ismael: Good morning, Miss Junjie.

Miss Junjie: Hello Ismael, napasayo lang atoang meeting kay nakagahin kog oras karong buntag. I'm currently checking the spreadsheet you sent me so pa confirm lang ko ha - ang goal sa inyohang system is silbi murag preliminary na alternative? Sakto ba?

Ismael: Yes Miss Junjie. Ang goal sa system is to be used for electronic guided-self assessment or basically an electronic na preliminary for thyroid diseases.

Miss Junjie: Ah ok! Maayo gani na nakahuna-huna mog inani na thesis ay. So ang imohang ganahan for this spreadsheet is akoang i-assess which of these are specific for hypo and hyperthyroidism noh?

Ismael: Yes miss if ever mn gni naay specific anah nila.

Miss Junjie: Kuan, nagbase mog existing study ani? Diin ka gkan sa kaning attributes kay nacurious lang pd kos iya study ay. Pwede ko mangayog link?

Ismael: Pwede kaayo Miss. Ako isend karon and mu-email kog link with a summary. Naa pud na siya'y serological attributes didto miss pero pathological man amoang focus for our system.

Miss Junjie: Ah I see. Kuan Ismael, kani silang mga attributes na imo gilista uniform rani sila for both hypothyroidism and hyperthyroidism. Pero ang response sa tawo ang makadecide if hypo or hyper ba kaha ang ilaha - pananglitan, kaning attribute nga *weight*, if mu-ana si person na grabe ila weight loss basin hyperthyroidism because paspas ang metabolism pero if weight gain basin hypo tungod hinay ang metabolism.

Ismael: Ah sige miss. Ako i-take down ni.

Miss Junjie: Kung akoang imaginon lang 'tahay ang inyo system Ismael, mahug siya og the more mu-input ang user, the more mufall iyang results sa specific dropbox - sakto ba nga term? Sige nalang, pero ou, mahug ug murag the more responses from them the more siya mu-fall to a specific disease.

Ismael: Pero would you say mao ni sila ang mga klase sa pangitaon inig preliminary or consultation miss?

Miss Junjie: Ou mao ni silang mga pangitaon. Naa pakay ganahan ipangutana?

Ismael: If okay ra miss.

Miss Junjie: Sige sure. Uy by the way, ayaw lang gamitan ang term "condition" ha since sex and age are factors kay "pathological factors" lang.

Ismael: Ay hala, thank you miss. Sige ako i-note rn. Kuan miss, diba even with pathological and serological attributes, ang doctor ara paman mu give ug final verdict jud once naay laboratory testings?

Miss Junjie: Yes, physical assessment, most of the time kay pang predict mn lang, imo testing ang confirmatory. Pangutan-on ka daan ani para mahint kung

unsay disease nimo. Based sa iya assessment sa imoha, makahibalo kung what kind of laboratory testing ang i-ask. Daghan baya og testing, so kung di ka mapangutan-an og doctor or if ikaw mismo walay ma-assess sa self, mahutdan kag take og daghan na testing.

Ismael: But possible raman jud nang mag guided self-assessment through pathological attributes Miss, sah?

Miss Junjie: Yes, kung baga mao nah sila ang ipangita igka consultation or kanang preliminary. Kanang physical assessment mga pathological attributes mana sila. Importante kaayo na makapangutana ang doctor og as much as he can para mas ma narrow down niya kung unsa kahay likelihood na kani ang iya sakit.

Ismael: Kuan miss, would you say makatabang or serviceable ang amoang system with its purpose karon?

Miss Junjie: Ou. I think butngan nimo dapat og emphasis ang help niya sa pagka preventive Ismael para mas muhit para sa uban. Kung self-check siya, and magthink ko na naay history of thyroid disease ko tapos makadungog ko about aning Thy-Sys, pwede jud ko mugamit, magself-check ko if taas kog likelihood.

Ismael: Hala miss salamat sa vote of confidence. Kuan lang pd miss, naa diay tuy concern sa amoa bahin sa false positives og true negatives. Like kung amoang system muingon nga “naa kay likelihood” aning sakita pero pagka laboratory na test kay negative daw. Flaw ba jud na siya sa amo system mismo miss? Diba naay inana pd na instances jd even without our system?

Miss Junjie: Ou naa jud ing-ana even karon. Wala’y ratio pero it’s part of the process jud.

Ismael: Dili ba ma-render og sayang ang ila gasto Miss? Di ba dili dapat?

Miss Junjie: Dili jud sayang. Mas malipay gani ta dapat diba kung mu-negative atoang results. That's why dili dapat magpacheck up lang kung malala na. In the case sa lumps sa throat sa imo mom last year, pwede mn jd to siya ma benign or malignant. Pero need gyapon magpa check to confirm it. Mas maau nang mupacheck ka pero benign kaysa sa wala ka nagpacheck dayon malignant diay. Ang point sa pag-pacheck up is dili lang man na makakita tas sakit nato, apil napud anah ang makita na wala diay tay sakit. Dapat jud malipay if negative ang nigawas sa lab test mismo. So mao to, dili jud dapat magpacheck up lang kung naa najd tay gipamati. Hehe

Ismael: Thank you kaayo, Miss Junjie ha? Gigahinan jud nimog oras na makig-meet nako run.

Miss Junjie: Wala ju'y blema Ismael. Plano mani ninyo idevelop diba?

Ismael: Yes Miss hinaot.

Miss Junjie: Goodluck Ismael! Hinaot ma-approve namo ani ha. Nya kung magkahiunsa kay chat lang jd paagi sa messenger sa imohang mama. Regards pud ko.

Ismael: Will do, Miss Junjie.

Miss Junjie: Kuan, muemail pd nya ko balik with my comments ha sa spreadsheet.

Ismael: Ok kaayo Miss. God bless you always.

-- End of Interview --

End Time: 11:30 a.m.

Transcript of Interview with Ma'am Lucila

***Date of Meeting*:** May 14, 2021 (Friday) 11:50am-12:30pm
Venue: Messenger Video Call
Meeting attendees: Ismael R. Francisco (researcher/interviewer) and Ma'am Lucila Francisco (interviewee)
Start Time: 11:50 a.m.
End Time*:* 12:30 p.m.

-- Start of Interview --

Ismael: Hi ma, so basically mangutana lang ko bahin sa importance sa self-assessment for you, how you are diagnosed and about checkups.

Ma'am Lucila: Sige nak. Sa self-assessment, nakafeel kog lump sa ako throat. Actually dugay na, kadto palang si ate pa nimo ang youngest. Pero we didn't have the resources to get a check-up labe na nga I had 3 students in school and imo papa wala nato kay navy baya.

Ismael: So adto najud ka naka pa check nga nanarbaho na sila kuya diay ma?

Ma'am Lucila: Ou 'nak. Covered man ko sa insurance ni Kuya nimo saona so siya niingon na magpa check up ko. Una adto kay sa general medicine na doctor rako nya kadugayan gi-refer ko kang Doctor Ogalino, na mao puy na-surgeon nako.

Ismael: Hala ou. Ma 8 years old pako aning panahona dba? Mga 14 years ago mani.

Ma'am Lucila: Ou gamay paka adto kung dili ka 8 kay padong pa ka og 8 at least. Pero mao to, naka pa biopsy ko nya pagkahibaw na thyroid cancer, girefer ko sa kang Doc Ogalino. Di rapud dugay adto ma kay giopera na dayon ko, kadtong pagbisita nimo na dili pako makaspeak nak mao nato akoang thyroidectomy. After adto pajud kay maayo gani na naa si Doctor Tan kay

apparently need pako mag radiation. Dako kaayo tog tabang si Dr. Ogalino, kani laging wala tay knowledge prior about our thyroid, si Doc ang nag teach nako.

Ismael: Pero unsa gni to na stage imoha mama?

Ma'am Lucila: Stage 2 nak. Kuan pud diay, kung nakapacheck up daw ko adtong saona palang, pwede ra unta ko dili mag thyroidectomy unta kay madala ratog radiation para mahilis. Pero dili naman mabawi ang mga shortcomings so mulearn lang ta from it. Actually need pd ka dapat macheck up kay naay chance na naa nakoy TC adtong nabuntis ko nimo pero hinaot dili ra mainherit sa bisag kinsa ninyo na anak.

Ismael: Tawn sad ma. Pero kuan sd ma, last question lang diay, kanang mag-self check ka ba nya feel nimo naa napuy lump na malignant pero inig pacheck sa lab kay munegative, sayang bana sa money and time?

Ma'am Lucila: Dili jud nak. Peace of mind is priceless. The knowledge of what I have or not have is priceless. Actually before nag pandemic kay nakapacheck man kog usab adto kay abe nakog naa napu'y lump na cancerous.

Ismael: Ou ka-recall ko pero unsa gani imo mga lab test adto ma?

Ma'am Lucila: Pang blood work og biopsy, the usual. Pero negative ilahang result, so nibayad pakog pang CT scan as a final confirmation kay kung di daw kaya sa biopsy, basin naa sa CT scan. Pero pagka abot sa CT scan kay negative ra pud. Pero ang akoa anah 'nak is that at least I know what I have or don't have. That way ma-agapan sa doctor og nako through treatment and medication.

Ismael: Salamat ma.

Ma'am Lucila: Kuan, need pa ka ug additional interviewees? Pwede nato i-contact sila Ma'am Sansen and Ma'am Marlina labe na kaila to nimo.

Ismael: Pwede rajd mama. Thank you kaayo sa pagtabang.

Ma'am Lucila: Wala ju'y blema 'nak.

Ismael: Kuan ma, ok raka i-cite tika sa study diay?

Ma'am Lucila: Cge nak wala juy blema.

Ismael: Thank you ma.

Ma'am Lucila: Way blema. Ato tong imessage sila Ma'am Sansen and Ma'am Marlina unya.

-- End of Interview --

End Time: 12:30 a.m.

Transcript of Interview with Ma'am Sansen Cafe

***Date of Meeting*:** May 14, 2021 (Friday)

Venue: Messenger Video Call

Meeting attendees: Ismael R. Francisco (researcher/interviewer) and Ma'am Sansen Cafe (interviewee/THYCA Fighter member) and Ma'am Lucila (co-interviewer)

Start Time: 1:00 p.m.

End Time: 2:30 p.m.

-- Start of Interview --

Ma'am Lucila: Hello Ma'am Sansen!

Ma'am Sansen: Hello Ma'am Lucila! Kuan, bahin ni sa kadtong thesis ni Ismael noh?

Ismael: Yes Ma'am. Maayong hapon diay.

Ma'am Lucila: Ok raba nakigmeet mi nimo run?

Ma'am Sansen: Ou ok ra jud. Pangutana lang kay ato na tabangan.

Ismael: Kuan Ma'am Sansen, mu-ask unta mi bahin sa imong diagnosis.

Ma'am Lucila: Yes ma'am, kanang giunsa nimo pagka diskubre nga naa kay thyroid cancer?

Ma'am Sansen: Kalit-kalit rajd to siya. Nahikapan sa throat. Unya murag naa'y bugon nga gahi murag liso.

Ma'am Lucila: Unsa kadak-on ma'am?

Ma'am Sansen: Murag liso sa nangka.

Ismael: Kuan, pila ka years ago gni ni siya ma'am?

Ma'am Sansen: Kuan, 10 years ago man uroy kay 2011 man ko naka-pacheck-up jud.

Ismael: So di ra dugay after nahikapan to nimong burot ma'am kay nagpa check-up dayon ka?

Ma'am Sansen: Ou. Sige'g check-up nya kadugayan gi-operahan dayon ko. Pero before gi-operahan ko ni-agi sah jd kog biopsy.

Ma'am Lucila: Kuan man, papillary carcinoma man sd ka noh?

Ma'am Sansen: Yes ma'am.

Ismael: So after opera nimo Ma'am Sansen, ni-agi pakag radiation pud ba?

Ma'am Sansen: Ou pero wala dayon pagkahuman og opera kay wala man ko kahibaw nga kinahanglan diay.

Ma'am Lucila: Wala diay ka giingnan sa nag opera nimo, Ma'am?

Ma'am Sansen: Wala ma'am. Di mn to personal jd na doctor gud kay ni-agi man ko'g charity program adtong akoang opera. Igo rako gi-referran og surgeon dili jud personal doctor parihas sa atoang Doctor Tan run ba. Wala pud dayon ko naka-balik og checkup pagka human og opera dala sa kahadlok. Pero pag pangutana nako adtong nag-opera nako ni-ingon man to siya nga dili ra ko kailangan mu=agi og radiation. Pero pag-ingon sa lain na doctor kay need na jud diay kog radiation. Anah si Doc nga ang stage 1 palang i-radiation naman gani. Unsa nalang ko nga stage 2 thyroid cancer diay. Kani laging wala tay alamag saona Ma'am ba.

Ismael: Ma’am mangutana lang pd diay ko. Sayangan ba ka anang munegative ang test results? Kanang pananglitan pag self-check nimo kay feel nimo naa kay sakit pero ni-negative diay.

Ma’am Sansen: Mas mahiluna jud hinuon ko dong Ismael kung mu-negative. Maskin nag mugasto ka at least kaybaw ka kung unsay naa or wala nimo ba. Kuan gani akoang manghud nakahikap sd og burot sa iya tutunlan. Abe pd namog cancerous - pero pag lab test niya kay benign rapd tawn kaluoy sa Ginoo. So mao na, importante gyapon ang checkup bahala’g unsay resulta.

Ma’am Lucila: Salamat kaayo Ma’am, tabang kaayo ni sa iyahang thesis.

Ma’am Sansen: Ay ou dong Ismael unsa jd diay inyohang thesis?

Ismael: Maghimo bali mi og system Ma’am nga maka-tabang sa people og predict kung naa ba silay likelihood na magka hypothyroidism or hyperthyroidism hehe muinput sila sa ila symptoms bali na icalculate ang likelihood.

Ma’am Sansen: Uy kanindot gud. Na inspired diay ka sa imoha mama. Very good.

Ma’am Lucila: Salamat kaayo Ma’am Sansen. Mubalita lang kog tiwas nimo sa chat ha kung unsa pa gni.

Ma’am Sansen: Cge Ma’am. Amping mo diha ha and Goodluck.

Ismael: Salamat Ma’am! God bless always.

-- End of Interview --

End Time: 2:30 p.m.

Transcript of Interview with Ma'am Marlina Verdida

***Date of Meeting*:** May 14, 2021 (Friday)

Venue: Messenger Video Call

Meeting attendees: Ismael R. Francisco (researcher/interviewer) and Ma'am Marlina Verdida (interviewee/THYCA Fighter Member) and Ma'am Lucila (co-interviewer)

Start Time: 3:00 p.m.

End Time: 4:00 p.m.

-- Start of Interview --

Ma'am Lucila: Hello Ma'am Marlina. Kagwapa ba sa akong miga uy.

Ma'am Marlina: Hi Ma'am! Miss you na. Hehe buyag uy.

Ma'am Lucila: Pero bitaw Ma'am nanawag lang ko bahin sa thesis ni Ismael kay need silag iinterview. Ok raba?

Ismael: Hello Ma'am Marlina.

Ma'am Marlina: Hello dodong! Ok ra jud kaayo. Kuan, bahin sa thyroid diay imo thesis dong?

Ismael: Yes ma'am silbi maghimo mig system na makatabang sa taw mag self-assessment unta so mangutana ta kos inyoha pung experience og ideas. Ma'am Marlina,muask unta ko kung giunsa ka pagka diagnose?

Ma'am Marlina: Ay kuan, nagsugod to nga cge kog kakutasan, dali rako maluya ba. Abe namo highblood or sa kasing-kasing to nako.

Ma'am Lucila: So ni-agi sa kag laing klase na doctor?

Ma'am Marlina: Ou ni-agi sa ko'g general doctor. Niagi kog electrocardiogram or ECG, x-ray nya puro negative. So dili jud diay to siya high blood. Kadugayan ang

general doctor ni ingon na mu-take ko'g thyroid ultrasound. So mao to nga nakit-an nila na naa koy gamay na mass sa tubo para hangin nako.

Ma'am Lucila: Ah wala diay kay nahikapan na lumps sa tutunlan Ma'am?

Ma'am Marlina: Wala rajud ma'am. Mao pud diay tong wala kay small paman daw ang mass. Pero mao lgi to kutasan ko nya maglisod usahay og ginhawa. Nag absolute thyroidectomy dayon ko para dili muspread.

Ismael: Kuan ma'am, how long na sukad sa imohang operation?

Ma'am Marlina: 2013 man to so mga 8 years na bali.

Ismael: Adto ra jud diay sa ultrasound nahibaw-an ma'am noh?

Ma'am Marlina: Ou dong. Kung wala pa tung thyroid ultrasound wala pd unta koy alamag kung unsa ang naa nako.

Ismael: Kuan sad unta ma'am mangutana ta ko nimo bahin sa inyohang mga check-up ba, dili raba mo sayangan kung mu-negative ang resulta?

Ma'am Marlina: Kuan jud dong, since naa na mani namong sakita, not a concern of wasting money najud na siya kay dapat routine na among check-ups maong dili jud siya sayang. Pero para sa mga wala pa aning sakita, angay gihapon sila mu-pacheck up in general kay lisod na nang apiki na kaayo ta mu-pacheck up kay ang atoa anah mahibaw-an daan unsaon og sulbad ba.

Ma'am Lucila: Mao jud ma'am, pari-parihas mog idea ni Ma'am Sansen ay.

Ma'am Marlina: Ou uy kay ang atoa ba kay part naman jud nis atoang life. Mas malipay pako uy kung negative kay at least dili dagdag sa problema gani. Pero if positive sad, malipay lang ta kay nahibaw-an so mahibaw-an sd unsaon ang treatment.

Ismael: Salamat kaayo Ma'am Marlina. Mu-update ra pud nya ming mama sa imoha bahin ani ha.

Ma'am Merlina: Cge dong wala juy blema.

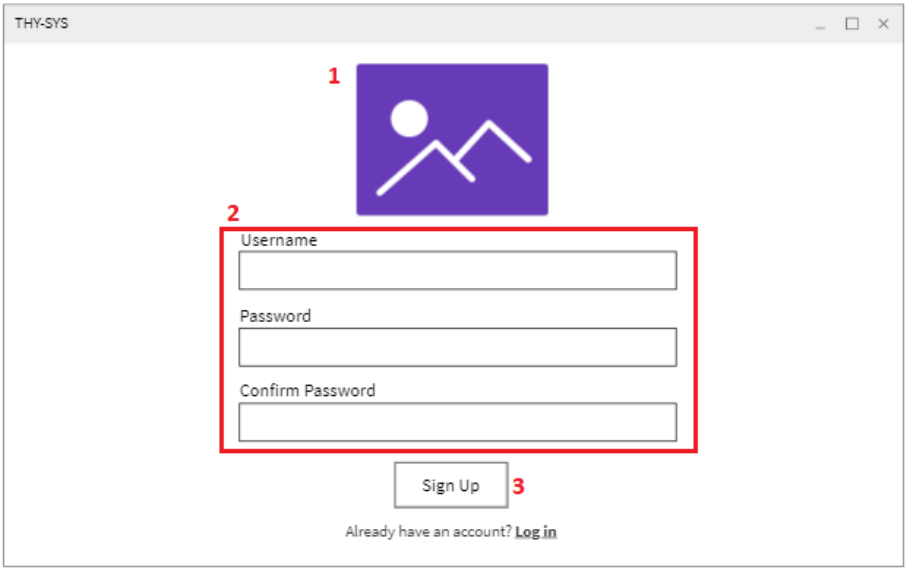
Ma'am Lucila: Salamat Ma'am Marlina. Amping kanunay.

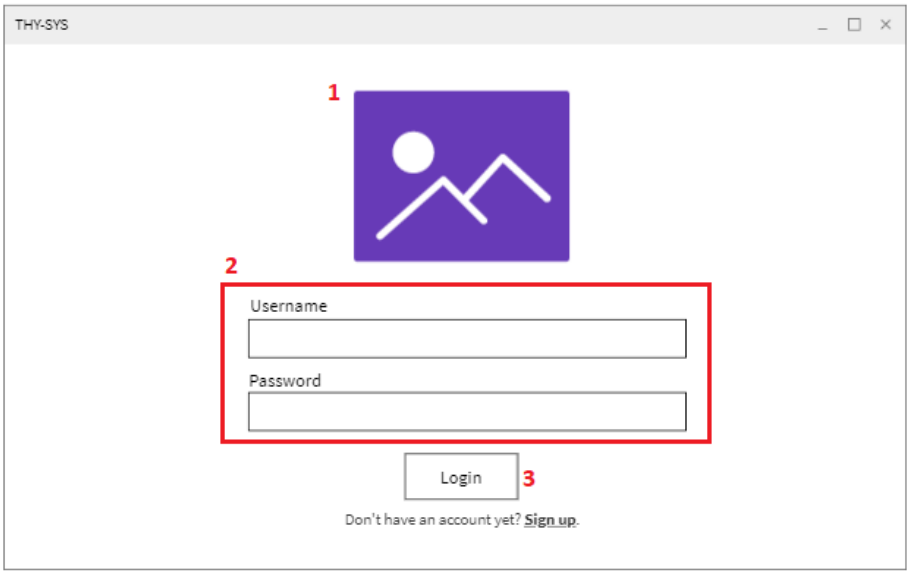
-- End of Interview --

End Time: 4:00 p.m.

Appendix C

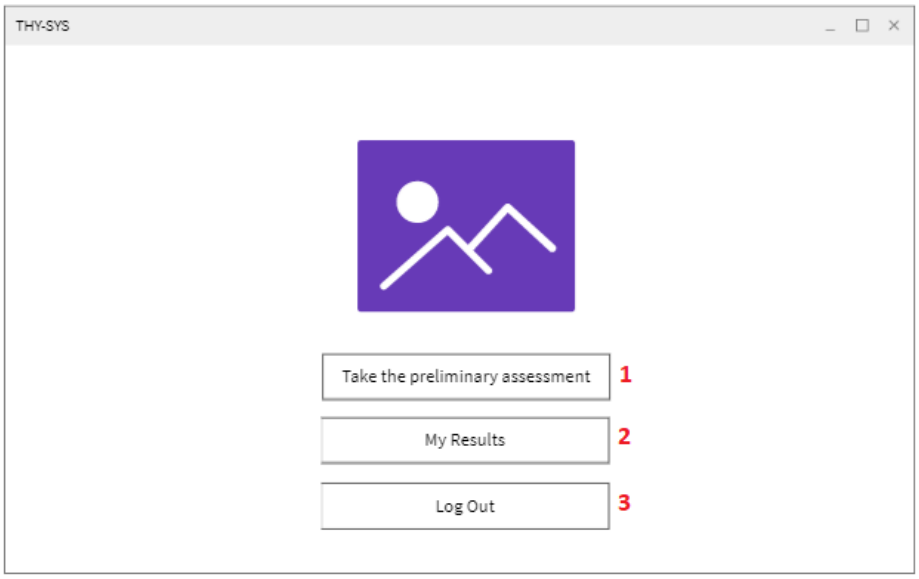
Software Requirements Specification





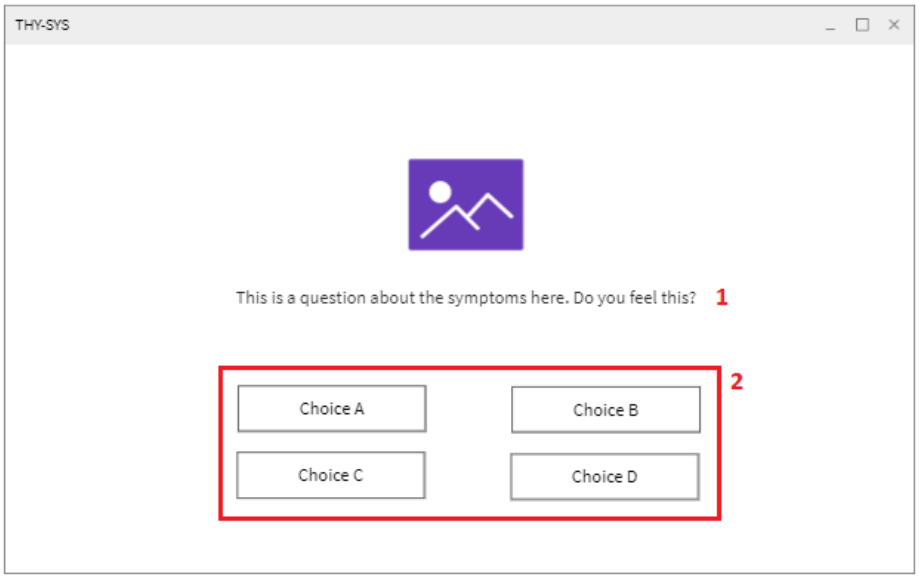
Login and Sign up Page

1. Thy-Sys Logo Image
2. Input forms (collects the username and password)
3. Login / Sign up button



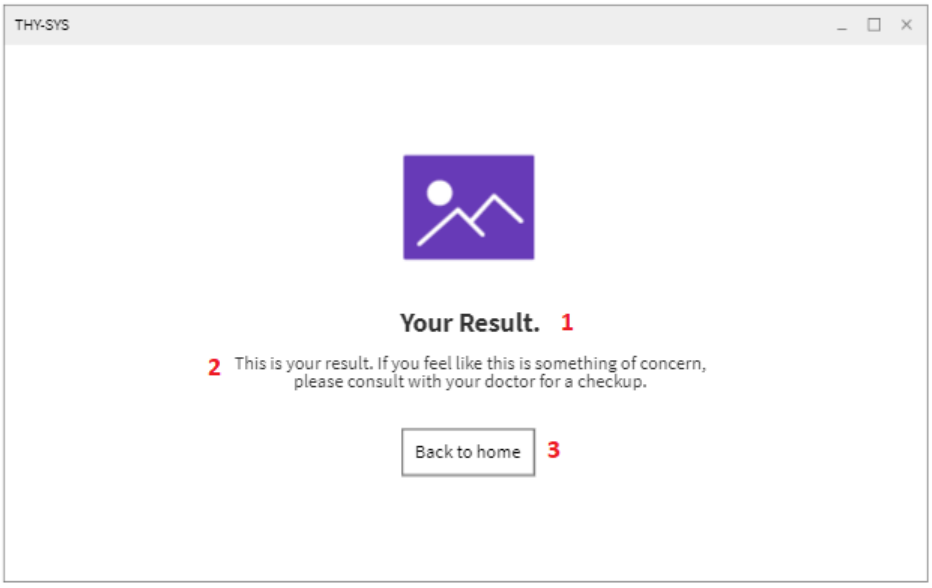
Main Menu

1. Leads to the page where one takes the preliminary assessment
2. Leads to the page where results of the test are displayed, if any.
3. Logs out and leads to the login page once more



Assessment Page

1. Question regarding the signs and manifestation of the disease
2. Multiple-choice response to the question

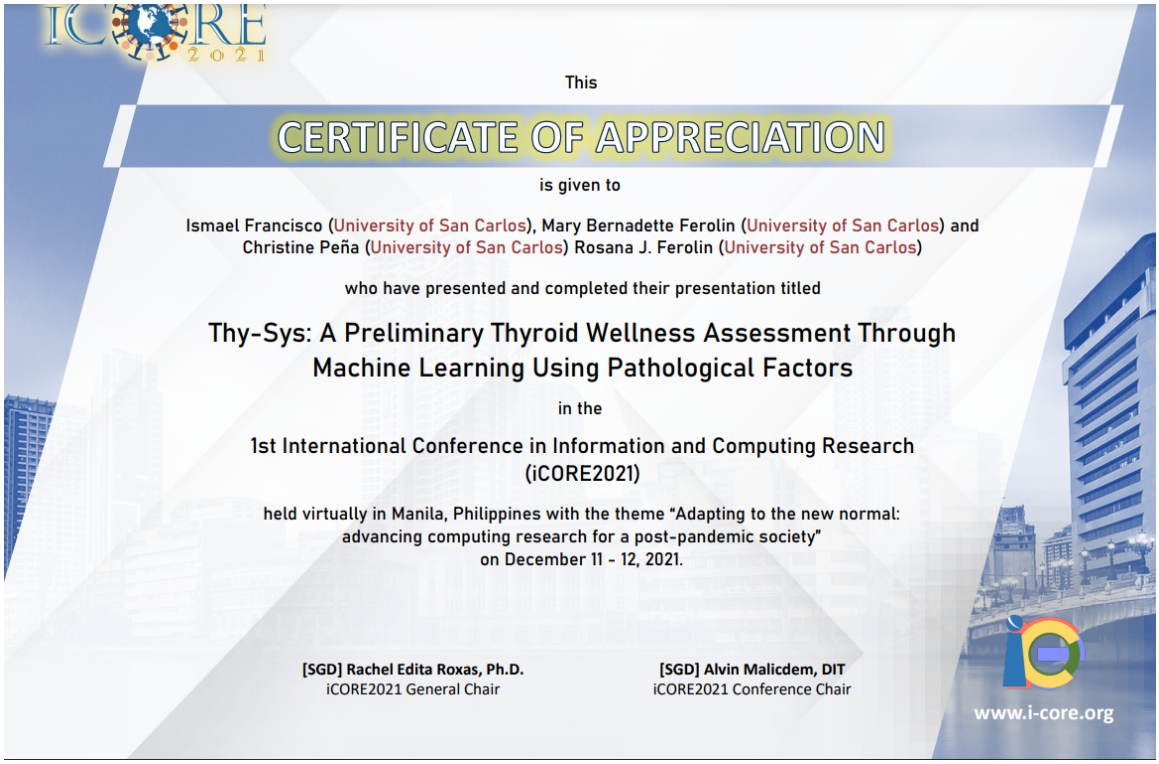


Results Page

1. The result based on the response (normal or not normal function)
2. A message about going to the doctor if the observed characteristics are concerning or alarming
3. Leads back to the main menu page

Appendix D

Certificates



This

CERTIFICATE OF APPRECIATION

is given to

Ismael Francisco (University of San Carlos), Mary Bernadette Ferolin (University of San Carlos) and Christine Peña (University of San Carlos) Rosana J. Ferolin (University of San Carlos)

who have presented and completed their presentation titled

Thy-Sys: A Preliminary Thyroid Wellness Assessment Through Machine Learning Using Pathological Factors

in the

1st International Conference in Information and Computing Research (iCORE2021)

held virtually in Manila, Philippines with the theme "Adapting to the new normal: advancing computing research for a post-pandemic society" on December 11 - 12, 2021.

[SGD] Rachel Edita Roxas, Ph.D.
iCORE2021 General Chair

[SGD] Alvin Malicdem, DIT
iCORE2021 Conference Chair

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accenture

Accenture in the Philippines presents this

Certificate of Recognition

to

Ismael Francisco
Mary Bernadette Ferolin
Christine Pena
Rosana Ferolin
(UNIVERSITY OF SAN CARLOS)

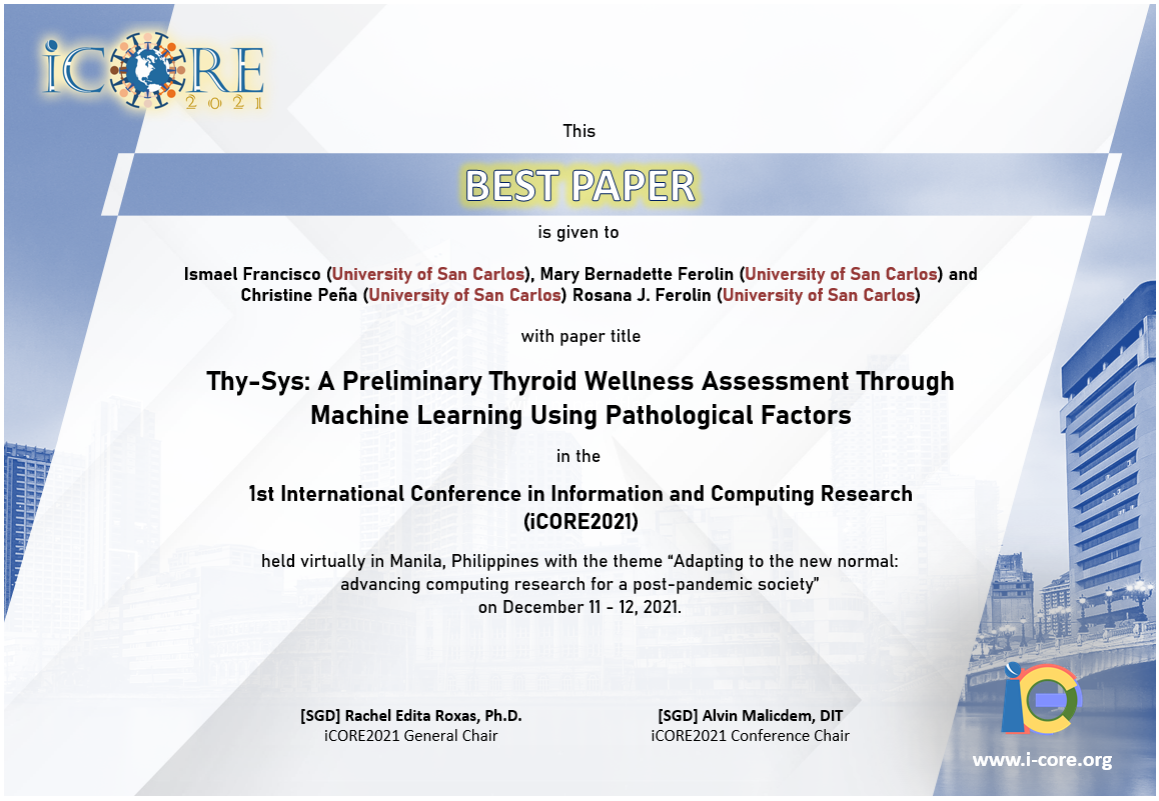
with paper title

Thy-Sys: A Preliminary Thyroid Wellness Assessment Through Machine Learning Using Pathological Factors

For winning the **Best Paper** (Sponsor Category) in the
1st International Computing and Information Research 2021 (#iCORE2021) with the theme:
"Adapting to the New Normal: Advancing Computing research for a post-pandemic society"
on December 11 – 12, 2021 in Manila, Philippines.

Alex B. Gomez
HR Recruiting Manager

Andrea Ranaika B. Basinillo
Judge


iCORE 2021
This
BEST PAPER
is given to
Ismael Francisco (University of San Carlos), Mary Bernadette Ferolin (University of San Carlos) and Christine Peña (University of San Carlos) Rosana J. Ferolin (University of San Carlos)
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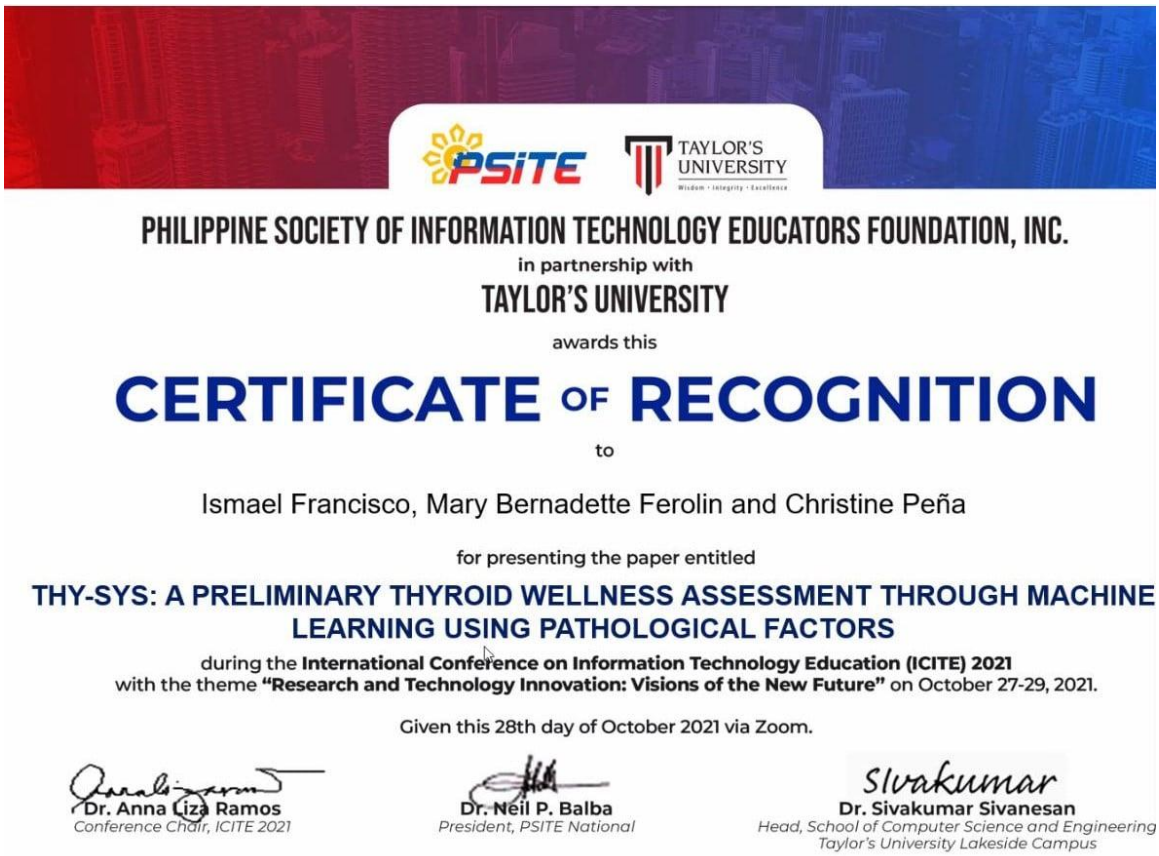
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awards this
CERTIFICATE OF RECOGNITION
to
Ismael Francisco, Mary Bernadette Ferolin and Christine Peña
for presenting the paper entitled
THY-SYS: A PRELIMINARY THYROID WELLNESS ASSESSMENT THROUGH MACHINE LEARNING USING PATHOLOGICAL FACTORS
during the International Conference on Information Technology Education (ICITE) 2021
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Appendix E

Published Paper

Thy-Sys: A Preliminary Thyroid Wellness Assessment Through Machine Learning Using Pathological Factors

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***Abstract*— The thyroid gland is a butterfly-shaped organ located lower front of the neck that plays a critical role in one's overall well-being. According to survey, thyroid dysfunction is observed in 8.53% of Filipino adults aged 42 to 62 years old, implying that 1 out of 12 Filipino adults has some form of thyroid function abnormality. To promote awareness of thyroid health, the researchers developed the Thyroid System for Wellness Assessment (Thy-Sys) which aims to determine the wellness of a person's thyroid through machine learning. The system assesses the user's thyroid wellness based on their responses to questions related to observable characteristics of the more common thyroid diseases like hypothyroidism and hyperthyroidism. Prior to the development, four machine learning models, Support Vector Machine (SVM), K-Nearest Neighbors (KNN), Decision Tree, and SVM-KNN were evaluated in classifying the state of the thyroid through pathological factors. Training and testing of the machine were done over a dataset with 1,464 entries and a total of 18 pathological attributes. 10-fold cross-validation was performed to verify the models' accuracy while observing other metric scores. The SVM-KNN model garnered the highest accuracy of 99.55% with 98.75% precision, and 98.61% recall and F1 scores, and was integrated into the system.**

Keywords*— *Thyroid disease, Machine Learning, SVM-KNN, Decision Tree, Predictive Model

I. INTRODUCTION

Prior to the COVID-19 pandemic, it has been a common observance that a number of people avoid utilizing and availing the different public healthcare services. A study [1] shows an assessment of the reasons why this trend is so. Through a conducted survey with the general public in the U.S., reasons for avoiding medical care were categorized, with emphasis placed on three major categories - low perceived need for medical care, traditional barriers from obtaining such care, and unfavorable evaluation when it came to seeking medical care. But because of advancements in the medical field, the purpose and aim of medical care has also evolved. Now, seeking medical professionals and their help has become a form of preventive healthcare where it is taken as an opportunity to learn more and be educated to know what to do in case of unfavorable diseases or conditions - this would not have been the case years ago when seeking medical professionals ultimately meant that one was sick [2].

One of the important systems of the body is the endocrine system. It is a unit of different glands located all over the body - glands which secrete chemicals called "hormones" that enter the bloodstream, traveling to other parts of the body. The endocrine system is vital to the bodily functions of a human because it helps in regulating the homeostasis as well as the difference in the body's reaction to different internal and external stimuli. The thyroid gland is a 2-inch butterfly-shaped organ at the front of one's neck, but is a major gland in the endocrine system which affects most, if not all, organs in the body. It is the gland that controls metabolism, breathing, body temperature, cholesterol levels, the heart and nervous system, menstrual cycles, and even brain development [3].

One of the most common disorders of the endocrine system is thyroidal. The hypothalamus, the brain part of the endocrine system, is responsible for the production of the thyrotropin-releasing hormone (TRH), which signals for the release of thyrotropin or the thyroid-stimulating hormone (TSH), which, in turn, stimulates the thyroid to produce the thyroxine (T4) and triiodothyronine (T3) [3]. One thyroid disease called hypothyroidism is usually the result of the lack of iodine in the body obtained through one's diet, while hyperthyroidism comes as result of an overactive thyroid [4]. In addition, the risk of thyroid diseases is dependent on an individual's lifestyle [5], and whether or not there is a history of thyroid disease in the family. Thyroid diseases typically have various visual manifestations like how hyperthyroidism is manifested through high blood pressure, diarrhea, rapid heart rate and weight loss or how hypothyroidism is associated with fatigue, dry skin and hair and weight gain. A study [6] of the prevalence of thyroid diseases in the Philippines shows that among a total of 4897 whose thyroid functions were tested, 8.53% of whom had

thyroid dysfunction, with 2.18% and 0.4% having subclinical hypothyroidism and true hypothyroidism, respectively, and with 5.33% and 0.6% having subclinical hyperthyroidism and true hyperthyroidism, respectively.

The current circumstance which encourages most citizens to stay at home has put a strain on the availability of direct access to physical checkups, thereby impacting the confidence of individuals in visiting medical establishments who seek for appropriate medical advice. Moreover, it has placed emphasis on the need to maintain one's well-being. The researchers sought to extend the said study that used machine learning algorithms in the prediction of thyroid diseases by creating an initial self-assessment system, which uses one of the established machine learning algorithms in the evaluation of an individual's thyroid wellness.

II. Background

A. Computer and Medicine

Technological advancements like information management systems provide convenience and efficiency in the manipulation and access of records and other data. One study [7] seeks to establish how crucial and beneficial computer techniques are in the field of medicine and health. Moreover, Computer Assisted Decision Making (CMD) has also provided doctors assistance in the diagnosis, prognosis and remedies of diseases. This allowed for faster analyses of blood samples and microorganisms, a critical advantage in data retrieval and therapy.

In addition, there is a growing recognition for the usefulness of artificially intelligent systems and machine learning to physicians for its potential of not only doing a physician's work more accurately and efficiently, but also promoting the safety of patients [8].

B. Predictive Technology in Thyroid Studies

Technological advancements have been applied in various ways in the area of medicine. In 2016, the use of AI has become a notable phenomenon in the medical field, with its objective of automating the diagnoses of various diseases, relieving part of the doctor's obligations and redirecting more time to activities that require attention and cannot be automated [9].

An expert system [10] called the Expert System for Thyroid Disease Diagnosis (ESTDD) diagnoses thyroid diseases utilizing dataset from the UCI repository. Using a neuro-fuzzy hybrid method, ESTDD had a 95.33% accuracy in predicting thyroid diseases, considering five features of the dataset. Notably, the study aimed to provide assistance to doctors even with limited expertise in computers. More than that, information collected may be a valuable educational tool for students studying endocrinology.

On the other hand, Tyagi, Mehra, and Saxena [11] conducted an evaluation of the different machine learning algorithms. The study utilized datasets from UCI and resulted with SVM having the highest accuracy of 99.63%. Similar results were also obtained by Duggal and Shukla [12] in their study of predicting thyroid diseases among three ML techniques (SVM, NB, and Random Forests). Likewise, classification models were created by Shankar, Lakshmanaprabu, Gupta, Maseleno and de Albuquerque [13] using a multi kernel support vector machine (SVM), whose accuracy, sensitivity, and specificity garnered 97.49%, 99.05%, and 94.5%, respectively.

A study by Mir and Mittal [14] proposes a hybrid machine learning framework for the prediction of Thyroid Diseases. Using datasets collected from the SMS hospital, containing pathological and serological attributes, the hybrid model, using the Bagging algorithm, garnered 98.56% accuracy in its prediction using both serological and pathological features.

Furthermore, Dharmarajan, Balasree, Arunachalam, and Abirmai [15] use patients' blood samples in order to differentiate thyroid disease diagnoses. Results of the study showed that the decision tree garnered the best accuracy with 97.35%, followed by SVM with 95.3%, KNN with 94.2%. The study also mentions conditions such as weight loss or gain, swollen neck or goiter, change in heart rate, hair loss, diarrhea, and menstrual irregularities, symptoms of thyroid diseases which harken to the attributes utilized by Mir and Mittal [14].

In addition, the use of thyroid hormones T3, T4, and TSH in another study [16] sought to determine the thyroid conditions hyperthyroidism, hypothyroidism, and euthyroid through a J48 classifier decision tree, Random tree and Hoeffding. These provided accuracies of 99.12%, 97.59%, and 92.37% respectively. Through the use of an ensemble technique, they were able to provide a relatively better accuracy of 99.2% with a sensitivity of 99.36%.

III. Methodology

A. Data Collection and Treatment

The data used in the study are collected from an existing study done by Mir and Mittal [14], which collected the information of persons who had thyroid problems, specifically hyperthyroidism and hypothyroidism, and persons with a normally functioning thyroid. The data set contains 1,464 entries, with 21 features and one class attribute. Of the 21 features, 18 of which are pathological factors while 3 are serological. In this study, focus is placed on the use of the pathological factors with the objective of having a system that uses factors which are more visible and observable by a person, so that it is directly usable and accessible to people, especially to those deciding to seek medical help.

The data are initially stored as a CSV file. The entries contained in the file are categorical in nature, and are then recoded into a numeric equivalent through the use of IBM SPSS Statistics 25. Through Google Colab along with a variety of Python libraries (e.g. Scikit-Learn, NumPy, Pandas, etc.), the data is pre-processed, so that features of the pathologic type and the class attribute are while the other features, as well as duplicated rows, are dropped. Rows with null values were also dealt with accordingly, and the dataset is split (80-20), so that a training and testing set is obtained.

B. Model Selection

Four different supervised machine learning models were considered in the development of the system – SVM, KNN, Decision Tree, and a stacked SVM-KNN model. Each of these models are trained on the training set and tested on the testing set. The results in testing the model were evaluated according to their accuracy, and other metrics such as precision, recall, and F1. Whichever of the model has the greatest performance, it is then integrated into the system and helps in the classification and prediction of thyroid diseases, or the lack thereof.

C. Implementation

Thy-Sys is a system that serves as an initial evaluation of the wellness of one's thyroid. Thyroid diseases come second as one of the concerns people go to endocrinologists for. Hence, the system attempts to determine the user's thyroid wellness, based on their responses to questions related to observable characteristics of the common thyroid diseases, such as hypothyroidism and hyperthyroidism. Should a thyroid disease be detected, a medical check-up is advised. The assessment is done through the use of a classification algorithm on the acquired data set. Hence, the application is now aimed to become a practical use of the studies that use machine learning in thyroid prediction.

Fig. 1 illustrates the flow of a diagnostic process, observed by doctors in the event of a patient visit, particularly for patients who are having their first consultation. The individual visits the doctor's clinic for a consultation about their concerns. The doctor first performs a physical assessment.

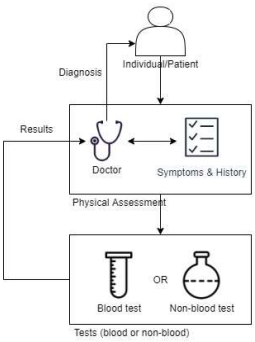


Figure 1. Diagnostic Process

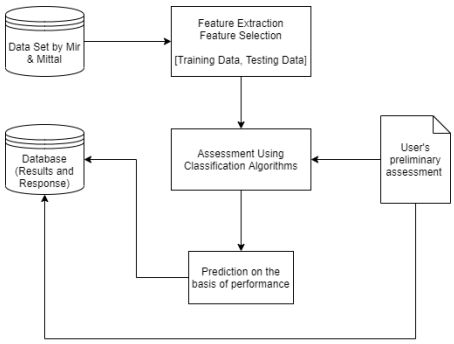


Figure 2. Thy-Sys Conceptual Framework

This comprises a thorough review and inspection of the individual's symptoms, family and medical history, which comprise the pathological factors considered in the study. The said assessment is done to determine the likely cause of the person's medical condition, and the appropriate test given to the patient.

Fig. 2 shows the system's main purpose, that is to provide an alternative preliminary evaluation for thyroid wellness. It should be noted that the system does not intend to replace official clinical checkup and diagnosis, but rather lead to it in order to confirm the state of a person's health. From the data set, the features used in the study (the pathologic attributes) are selected, and the instances within the dataset are used in training and testing the learner algorithm. The resulting model is validated on the basis of its accuracy in classifying the data as that of hyperthyroidism, hypothyroidism, and normal thyroid.

From there, the system is interfaced by the user through answering questions on the selected features used within the model. Responses are passed to the model and produce the results of the evaluation of the thyroid's condition (with disease or free of disease). A consultation with a medical professional is also be encouraged so that individuals may seek out for further testing and diagnosis. Fig. 3 provides a general view on how the users are to utilize the system created by the researchers. In a fashion similar to a preliminary survey, the users are to answer questions regarding symptoms of thyroid diseases. The responses are obtained and passed through a model.

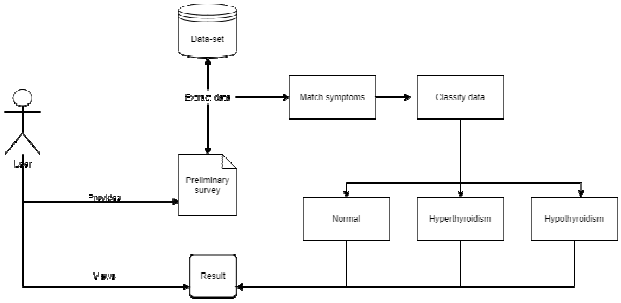


Figure 3. Use Case Diagram and Workflow of the System

The results of the assessment are derived through the model that was previously tested and trained. These results may also be viewed by the users.

IV. Results and Discussion

A. Machine Learning Model

Various studies have shown the possibility of predicting the presence of thyroid disease in a person based on a number of factors. Most of these studies give much of its focus to serological factors like levels of the hormones TSH, T3, and T4 present in one's blood. However, because of the pandemic, direct access to medical help has become very limited. Hence, the authors of this study committed to having a system that actualizes these studies, but with the use of pathological factors, which are more visible and observable by a person, so that it becomes usable and accessible to people, especially to those deciding to seek medical help. The system, then, aids the users on what factors and conditions are to be observed so that the self-assessment does not become ambiguous.

The developed system utilizes an ensembled machine learning model in assessing the user for the presence or absence of thyroid problems. This is based on their responses to questions pertaining to pathological factors commonly observed in said problem. During the training and testing phase of the development, three algorithms, namely SVM, KNN, and Decision Tree were initially considered. In addition, another model, which uses an ensemble technique called Stacking, was also considered. This new model is an aggregate of the based models, which has combined the capabilities of both SVM and KNN as learners. The dataset, initially containing 1,464 entries, now have 1,106 rows with 578 instances of "hyperthyroidism", 398 for "hypothyroidism", and 130 for "normal" thyroid condition. In this case, an imbalance of data between classes can be observed. Unfortunately, the performance of some of the classification algorithms are influenced by class imbalance – SVM, KNN, and Decision Trees are no exceptions to this behavior. To remedy this, Synthetic Minority Oversampling Technique (SMOTE) was employed to balance the number of dataset samples.

Table 1 shows the summary of results of the different models according to their accuracy.

TABLE I. Accuracy of the Machine Learning Models

ML Model	Accuracy (%)	
	No SMOTE	*SMOTE*
SVM	97.18	97.74
KNN	91.53	94.93
Decision Tree	96.69	97.29
Stack (SVM-KNN)	97.30	99.55

TABLE II. Metric Scores of the Machine Learning Models

ML Model	Metric Scores (%)		
	Precision	*Recall*	*F1*
SVM	95.63	97.38	96.12
KKN	92.50	96.39	93.20
Decision Tree	97.66	98.00	98.30
Stack (SVM-KNN)	98.75	98.61	98.61

The SVM model shows a generally good accuracy of 97.18% with the imbalanced dataset and an improvement of 97.74% with a more balanced training set. SVM classifiers are generally known to perform well and is one of the machine learning algorithms commonly used in classification and prediction. In addition, KNN, another commonly used classifier, classifies an object on the basis of the class of its *k* neighbors. The developed KNN model showed an accuracy of 91.53% and 94.93% when trained using an imbalanced and balanced dataset, respectively. The decision tree model also tended to garner a relatively better accuracy when oversampling is observed. However, based on the accuracy result, it is observable that an ensemble of both SVM and KNN garnered the highest possible accuracy of 99.55% when trained under a relatively balanced dataset, improving the accuracy from the performance of the two base models.

In addition to the accuracy, through the use of a 10-fold cross-validation method, the researchers were also able to obtain an average performance of the models through other metric scores (precision, recall, and F1).

Table 2 shows the different metric scores obtained from each model. All of the developed models showed to have generally high scores for precision, recall, and F1. However, once again, the stacked model shows the highest scores with 98.75% for precision, and 98.61% for both recall and F1.

Moreover, a confusion matrix also allows for a visualization of the performance of the model by revealing the number of correctly as well as incorrectly classified instances done by the model. The confusion matrix for the stacked model is shown in Fig. 4. The matrix shows that among the total 222 objects from the testing set, only one object has been misclassified.

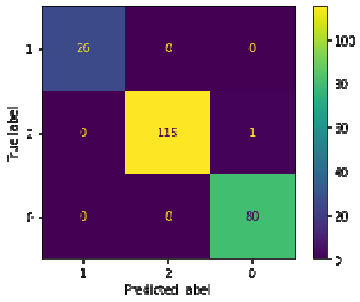
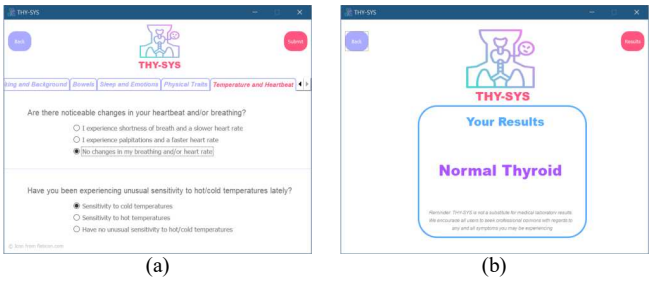


Figure 4. Confusion Matrix for SVM-KNN Model

(a) (b)

Figure 5. System Interface (Landing, Registration, and Login)



(a) (b)

Figure 6. System Interface (Assessment Process).

This particular object was placed under the class called "hypothyroidism" (labelled 0 in the figure) when it was meant to be classified as "hyperthyroidism" (labelled 2 in the figure). Thus, the matrix illustrates how each of the data is classified and offers a visualization of what a 99.55% accuracy looks like in terms of the actual objects within the testing set. This shows that the model not only does a good job of classifying but is also reliable in its performance of doing so. Furthermore, the consideration of the different metric scores of the model is crucial since the model is intended to be used in the real world and must be fed realistic data. This becomes especially more important since it is dealing with a person's health. By evaluating the models through their accuracy, precision, recall, and F1 scores, the SVM-KNN model was chosen to be employed in the development of the system.

B. System Implementation

The system is a desktop application developed using PyQT5, a Python toolkit which allowed the researchers to model the interface according to the workflow described in section 3.4. Fig. 5(a) shows the interface first encountered by the user every time the application is opened. Initially, the user registers their username and password, and is led to the menu, which allows them to log out, or to proceed and take the assessment or view their previous results, as shown in Fig. 5(b).

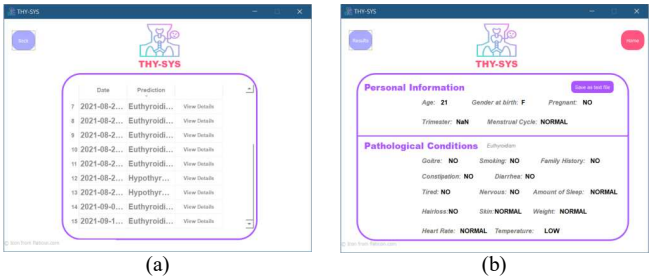
The developed system aims to be able to determine if certain conditions experienced by an individual, along with other pathological factors, belong to someone who is experiencing an excess, a lack, or sufficient amounts of thyroid hormones. For this to happen, a user should answer a series of questions pertaining to their age, gender, and other symptoms (e.g. constipation, heat intolerance, fatigue, etc.) related to the thyroid diseases focused in this study. This process is likened to that of the activities done during initial clinical check-ups, which focuses on getting to know what the patient is feeling, the reason for the patient's visit, as well as the duration and the possible factors contributing to the visit. Fig. 6(a) shows how the system does this by displaying questions on a particular symptom (e.g. heart rate, intolerance to certain temperatures, etc.), and enumerating a choice of responses to the question, resembling the different symptoms manifested and observed by the user taking the assessment.

The array of responses provided by the user is then sent to the stacked SVM-KNN model. The model now becomes responsible for the prediction of the presence or the absence of a thyroid disease, and returns a prediction. The result, shown after the user's submission, is the system's prediction based on the received array of responses, as in Fig. 6(b).

It is worth noting that the system is not intended to substitute clinical diagnosis, but rather support clinical assessment, and thus encourages individuals to seek medical help especially when necessary, potentially serving as a preliminary evaluation in the new normal mode of doing activities. Thus, the system also stores the current result and responses, as well as allows the user to view a list of their previous results, and the symptoms they have claimed to have observed, shown in Fig. 7. This is for the purpose that the user will not only be able to monitor their well-being, but also allow their healthcare provider/physician to have an idea of who their patient is and how they are, and aid them in the process of checking up and officially diagnosing the patient.

V. PRACTICAL IMPLICATIONS

A guided self-assessment makes individuals aware of the factors and conditions that contribute to the likelihood of contracting the disease and allows them to be conscious of its manifestations through the symptoms. The factors and symptoms used in the system have been verified by medical experts to be the things taken note of during consultations, particularly concerning thyroid. Moreover, it lessens the risk of individuals having to leave their homes to directly visit medical establishments and wait in the midst of a pandemic, while strengthening the justification to have a medical checkup most especially when the need arises.



(a) (b)

Figure 7. System Interface (Assessment Process).

VI. Conclusion

The thyroid, though small, is one of the most important organs of the body responsible in maintaining the body's overall homeostasis and regulating the body's responses to various stimuli. To monitor its state is vital and remedying any problems that could be experienced is crucial before it could potentially get worse. The study resulted in a system that allowed a computer application to determine the state of one's thyroid by examining the pathological factors which a person has observed. Prior to its development, three base models, SVM, KNN, and Decision Tree, were considered, and trained and tested under different data conditions. With a balanced dataset obtained through an oversampling method, SVM garnered the highest accuracy among the three base models, with 97.74% accuracy. In addition, a stacked model was also developed by creating an ensemble of two base learners, SVM and KNN. This resulted in a 99.55% accuracy, improving significantly than when only either of the models were tested, and was, hence, used as the machine learning model behind the system. The resulting system is not a replacement of official diagnosis, but a support for medical professionals in the process of diagnosing. Only laboratory tests can determine the definitive absence or presence of the disease, and while there are instances where the symptoms and diagnosis of the disease coincide with one another, it is also possible to test negative for the disease even with the manifestation of some of the characteristics described. Hence, the system serves as an initial assessment as well as motivator to seek a medical professional's help especially during this pandemic.

VII. Recommendation

For future studies, the authors recommend the collection and use of additional dataset for training and testing to improve the model performance leading to more robust results. Furthermore, other pathological factors related to thyroid diseases (e.g. difficulty in breathing, bulging of eyes, etc.) may also be considered features, to try and make predictions of thyroid diseases, based on such factors, more accurate.

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We send you all a heartfelt thanks.

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STI Academy - Pit-os
Elementary

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October 25-27
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CESAFI Computer Quiz Bowl

2018
First Semester Dean's Lister S.Y.

2018
Second Semester Dean's Lister S.Y. 2018-2019

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Able to work within tight schedules

CAREER OBJECTIVES

Further developed career path within machine-learning and artificial intelligence

REFERENCES

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    a. English (verbal and written)
    b. Filipino (verbal and written)
    c. Cebuano (verbal and written)
    d. Italian (written)
8. Computer PMS and software skills:
    a. C and C#
    b. Java
    c. NodeJS
    d. Flutter
    e. Dart
    f. Python and Flask
    g. PHP
    h. JavaScript

EDUCATIONAL BACKGROUND

1. Education Level

    Year: 2018

    School: University of San Carlos - Talamban Campus

    Senior High School

    Year: 2016

    School: University of San Carlos - North Campus

    *Junior High Schoo*l

Year: 2012

School: Maria Montessori International School (2010 - 2012)

: Marie Ernestine School (2006 - 2009)

Elementary

2. Certifications & Accreditations

2018 - 2021

Dean's Lister, School of Arts and Sciences

2015

NC II - Computer Systems Servicing

STRENGTHS/TRAITS & SKILLS

1. *Can work independently with minimal supervision and work with a team*
2. *Hands-on experience*
3. *Produce excellent outputs*
4. *Able to work within tight deadlines*

CAREER OBJECTIVES

To be able to hone my skills in development and start a company with my mother and a few of my closest friends, and finish a project with my mother.

References

1. Christian V. Maderazo, M.Eng
   Chairman
   Department of Computer, Information Science, and Mathematics (DCISM)

2. Blasminda Catubig Mayol
   Full Instructor 1
   Department of Computer, Information Science, and Mathematics (DCISM)

Resume update on 09/11/21