Longitudinal Ambient Mobile Sensor Monitoring for TCM-oriented Healthcare Assessments: Framework, Challenges and Applications

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ABSTRACT

Recently healthcare using information technology progressed with the maturity of tele-health monitoring services through Internet, and the emergence of mobile apps on smartphone s that are geared towards recording inputs of intakes (e.g. calories, fat, amount of water etc.), as well as monitoring one's activity levels (e.g. number of steps walked) and emotion states, for inferring one's health condition. In this paper, a novel concept of fusing the current mobile app software technology, big data, sensing technology, and machine learning (in decision rule induction, reasoning, and image recognition) into the principles of TCM healthcare is proposed. TCM has developed a set of practical, universal and thorough, and systematic health care system, which is notably characterized by its relations to our daily lifestyles. Currently it lacks of some ubiquitous tools such as mobile smartphone and its sensing apps to embrace this healthcare concept as a personal assistant, monitoring and advising the user regarding his/her health and forewarning of any health risk. The challenges and potential applications are discussed in this paper. The advantage of this project is tapped from the popularity and convenient use of mobile smartphone and EEG sensors for providing ubiquitous personal TCM healthcare.

Keywords

Healthcare application, data mining, mobile apps

1 INTRODUCTION

Health is always a prime concern for human-kind. Recently healthcare using I.T. progressed a lot with the maturity of tele-health monitoring services through Internet, and the emergence of mobile apps on smartphones that are geared towards recording inputs of intakes (e.g. calories, fat, amount of water etc), monitoring one's activity level (e.g. number of steps walked) for inferring one's health condition. In this project, a novel concept of fusing the current mobile app software technology, sensing technology, and machine learning (in decision rule induction, reasoning, and image recognition) into the principles of TCM healthcare is proposed and to be implemented. The advantage is harvested from the popularity and convenient use of mobile smartphone for providing ubiquitous personal TCM healthcare. The result is anticipated to be betterment in general health and well-being of residents. In this paper, we propose an IT-enabled healthcare framework that is consist of sensing and data mining technology, to be integrated and applied together along the direction of a case study of TCM healthcare philosophical system. The various technological components are to serve a common purpose/goal of improving the general well-beings of the users in a long term.

The proposed TCM[2] project is necessary, almost of urgency, to improve health and well-being. In modern societies, people are unknowingly consuming too much junk food, living an unhealthy life-style. According to the latest statistics[1], released by World Health Organization, which is a revised global and regional report of projections of mortality by cause for years 2015 and 2030, all causes of deaths are on the rise: at mortality rate of 7.91% to 8.46%. In particular, the top 5 killer diseases are forecasted by WHO to become more deadly; numbers of deaths (in 000s) per 100,000 population increase - heart disease from 105 to 112, stroke from 92 to 104, lung cancers from 23 to 29, Diabetes mellitus from 21 to 30, liver cancer from 11 to 14, from 2015 to 2030. Other reports commonly point to a fact that our health is higher risk than before in the near future.

Aging population is a world-wide problem, especially for China where the one child policy probably is a disaster. China is becoming an aged society. One of the greatest challenges for Chinese government would be the aging population, by 2050 there would be 45 people aged over 65 in every 100 people, comparing with 15 aged people in 2012. In fact, the "one-child-policy" side effects becoming the severe social and political issues; on one

WWW 2017, April 3-7, 2017, Perth, Australia.
ACM 978-1-4503-4913-0/17/04.
DOI: http://dx.doi.org/10.1145/3041021.3054936

[1] http://www.who.int/healthinfo/global_burden_disease/en/

hand it strongly impacts on the 1980s generation as they reach 30s or 40s, there is a high possibility that they have to look after 2 parents and 4 grandparents [1]. On the other hand, aging population also affects China's long-term sustainable development, the Chinese healthcare system in particular, the total healthcare expenditure increased from 11.02 billion RMB up to 658.41 billion RMB [2]. Therefore, our research on the mobile sensor monitoring for Traditional Chinese Medicine (TCM) orientated healthcare for personal assistant would be an invaluable contribution for the Chinese government to advocate individuals take responsibility to take care our bodies in daily life. Natural disasters cannot be controlled, but our personal health can be monitored by knowing the tell-tale signs from our body. TCM^2 can help increase health awareness by using ubiquitous computing technology.

2 Background

In the ancient medical text called 'Huang Di Nei Jing', it describes a vision of what healthcare should be today: preventive. TCM^2 is important because it is a system to detect the possibility of disease before symptoms have emerged. Premedical intervention before diseases is one of the principal practices in traditional Chinese medicine (TCM) for tackling health problems and diseases. Western biomedicine, the mainstream healthcare system, in modern societies, has become a scientific practice focusing on reductionism to the cellular level. Biomedicine treats illness that has already manifested because it has developed to the point where only diagnosable symptoms are treated. Thus it is reactive to the state of disease rather than proactive or preventive. In this project, TCM^2 emphasize on prevention and holistic health, which is designed to monitor and track wellness and suggest steps on continue and increase healthy patterns.

The fundamental technologies for constructing TCM^2 are available and they have been gaining popularity both in research and applications. They range from, biosignal sensor, image analysis, monitoring apps, cloud computing, machine learning to data mining etc. These technologies would have to be customized, tailor-made and modified for the case of TCM healthcare; basic examples of mobile apps on mainstream healthcare applications are on the market. They would be extended and enhanced in terms of prediction, decision rule inference, and throughout coverage over the comprehensive and complex concept of TCM healthcare. The core of this research is characterized by fusing a system of TCM philosophies into computer science and machine learning.

So far there are some mobile apps and online websites available along with the direction of promoting TCM. However, there is none so far that completes the full process from data collection in a similar approach as tele-medicine, analysis at the back-end and feedback recommendation to the users through some distributed cloud-computing platform. Such websites e.g. are as follow:

http://appcrawlr.com/ios-apps/best-apps-chinese-medicine,
http://completetcm.com
http://libguides.lib.cuhk.edu.hk/c.php?g=262526&p=2938785

All these sources only provide "information-based", 'guides" and "references", about TCM. There is no sensing, monitoring, analyzing, and auto-recommender functions. But in the latest report about TCM^2, published by WHO, it indicates the necessity of knowledge management (data collection) and engagement of TCM concepts into our daily life.

Technologically, there are supporting gadgets ready or potentially suitable for enabling a holistic approach such as TCM^2 which we are proposing here. Recently a paper is published based on remote diagnosis in TCM using Wireless Sensor Networks (WSN) [3]. WSN provides a wireless approach with better and easier access to the real-time data it can gather the data based on a wireless apparatus without cables which enables the user wearing it and moving around as they wish. However, as wearable embedded equipment, the wireless end user apparatus is limited in energy, communication bandwidth and ability to compute, so that the wireless apparatus have to be designed bearing those considerations in mind. There is an emerging trend that technologies are becoming more affordable too [4]. With the aid of WSN, advantages of the wireless affordable healthcare system: It allows people to self-monitor their health conditions at their convenience in an attempt to lighten the workload of doctors and nurses. Moreover, more people can benefit from the new system with much lower medical insurance fees due to the reduced risk of developing severe diseases through regular, long-term and effective monitoring of citizens' health conditions national-wide. For another instance [5], there are developments of low-cost and wearable healthcare monitoring system for pulse analysis in TCM. By using some low-cost system [5], significant physiological features can be obtained that reveal much information about human health condition. Also, they play a very important role in disease or symptom diagnosis through pulse diagnosis. For example, the P-point reveals the blood ejection condition of the human left ventricular, and the better myocardial contractility will result in the higher P-point value. The accuracy is as high as 86%.

Dating back to 2008, there have been some advances that make use of wireless networked Chinese telemedicine system [6]. The method and apparatus for remote pulse Information retrieval and diagnosis have been studied and tested. The information about health is contained in the five pulse tracings attributes in terms of "locations, frequency, rhythm, shape and force", respectively. Eigenvalue Extraction is to find the special point in the pulse wave which shows some information about health. Here we can pick up some important point such as Peak of Pulse, Trough of Pulse, and Peak of before dicrotic Pulse, Trough of dicrotic Pulse and Peak of dicrotic Pulse. The wireless networked system was implemented and the data analysis demonstrated the use of the possibility of telemedicine system in pulse information retrieval. The results indicate certain practical feasibility of the system to enrich remote medical care technology and to promote the further study on the TCM. Research on a networked remote medical care combining TCM is useful. It enables the traditional Chinese medical treatment and meets people's increasing health care requirement. The proposed wearable PCT apparatus provides a tool to detect the pulse information for the health diagnosis remotely. Individual apparatus can be connected to build a wireless network for information distribution. Experimental results indicated the practical feasibility of the system. This work has laid a foundation for further study on remote diagnosis of certain disease.

[2] http://apps.who.int/iris/bitstream/10665/92455/1/9789241506090_eng.pdf

3 PROPOSED TCM² FRAMEWORK

The TCM² project is the first in the market that integrate (1) sensing, (2) monitoring, (3) longitudinal time-series analysis, (4) image analysis, (4) lifestyle app, and (5) intelligent advisor functions. There are no similar apps developed so far to the best knowledge of the authors. As TCM advocates importance to the time structure of human body, our design emphasizes analysis on pathogeny and pathogenesis, and integrates cognitions that come from biology, physiology, psychology, environment, and our bodily reactions to them. TCM calls for prevention no less than cure and focus is founded on health preserving. Some of the most important methods of disease preventing and health preserving are to keep mental health and manage to keep balance in various aspects of bodily conditions [1]. This information can only be subtly collected over a period of time. Therefore, it opts to have a personal mobile app in monitoring a comprehensive range of bio-signals for analysis. So that feedbacks pertaining to TCM concepts could be derived and shown to the user as lifestyle recommendation. Under this framework, a mobile app called TCM² is developed that embraced three main components such TCM² data collection (TCM²DC), TCM² data analysis (TCM²DA), and TCM² auto-recommender (TCM²AR). Each of these three components would have to be supported by a buffet of I.T. technologies, which are shown in Figure 1.

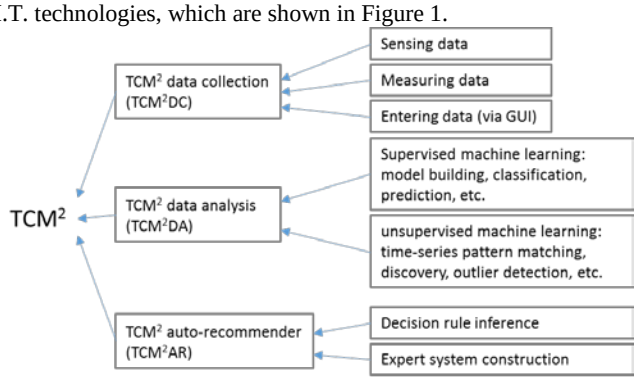

Figure 1: Abstract diagram of the design construct of TCM² system.

Although there are not short of algorithms and methods in the computer science and machine learning areas for satisfying the requirements of the three components, a holistic approach in trying out different methods with the aim of finding out the most appropriate methods is needed. Especially for TSM the diagnostic information is not apparently quantified when compared to western medication. Very few works have been conducted as a holistic approach, covering so much details of input signals, information of lifestyles, their inter-relations, associations, correlations and causality according to TCM-guided therapy and/or recommended lifestyles.

In this framework, a novel 3-in-1 model is suggested (as in Figure 1): data collection, data analysis and auto-recommender methodology, for implementing TCM healthcare using ubiquitous sensing technology, data analysis and expert reasoning systems. TCM² is scalable in design; when new measurement hardware becomes available, or additional TCM healthcare concepts are to be added, they could be adapted as new features into the system under the same computational framework without the need of redesigning the whole system. The remaining of this paper describes the TCM² methodology and its components in full details.

3.1 TCM²DC

The TCM² data collection component is responsible for collecting longitudinal, thorough, non-invasive and subtle data from a human user under certain schedule and over a certain length of time. Three sub-modules namely Sensing data, Measuring data and Entering data are meant to gather data/bio-signals for subsequent TCM-oriented analysis. By definition, the Sensing data (Sd) module collects data passively and continuously without the explicit awareness or constant intervention by the user. For example, pedometer keeps track of walking paces, wearable devices that estimate of calories burned, heart beat sensor, sleep sensor, and location sensor, etc. Fitbit wrist-band for instance, has an array of Sd functions, such as GPS tracking for distance, pace and elevation travelled, heart rate sensor, activity sensor and sleep patterns.

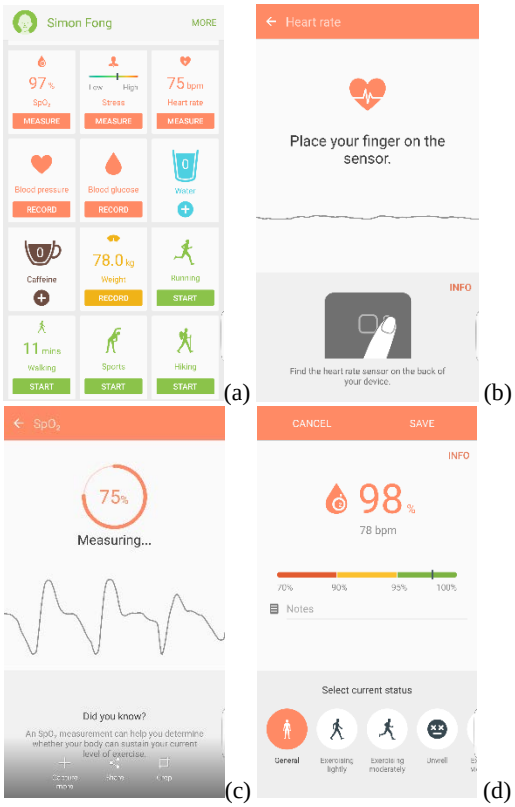

Figure 2: Sample GUI's and interface of data collection sensors.

The second sub-module is called Measuring data (Md) where the data collection is activated by the user. Data are being captured, usually by the user pressing a button, in various forms such as sensor measured data (e.g. blood pressure), image captured by camera, and voice recorded by audio microphone etc. For example, in some latest models of Samsung smartphones, bio-

sensor is in-built next to the pin-hole camera, and corresponding app called 'S-Health' was developed. In this design, the default measuring sensors similar to those functions by S-Health are used (without re-inventing the wheel). In Figure 2a, it shows a shortlist of Md functions (in orange) which require a touch-click for launching the measure, a shortlist of Sd functions measure or keeps sensing the data continuously, and other functions which the user have to manually enter the data (Ed) via a GUI. Figures 2b, 2c and 2d show an example on how Md would have to be pro-actively measured on the phone sensor.

Six additional "new" Md functions are developed, other than those standard functions which are currently available on S-Health, but specially catered for TCM diagnosis. They are (1) tongue evaluation (Md-Te), (2) facial-color evaluation (Md-Fe), (3) urine color evaluation (Md-Ue), (4) voice evaluation (Md-Ve), (5) emotion evaluation (Md-Ee) and (6) pulse evaluation (Md-Pe).

TCM diagnosis has a very comprehensive methods of evaluations, examinations and observations for signs or symptoms that may reflect as or lead to certain diseases [8]. A not-so-exhaustive list[3] [9] is shown in Figure 3. The list also matches with our six special evaluation methods which we develop in this project, in addition to those standard ones as shown in Figure 2a. All these six new Md functions are to be integrated into the standard sensing/measuring functions into the TCM^2 app. Collectively they together serve as data collection points from different perspectives and sources from the user's body for establishing the TCM^{2}DC module.

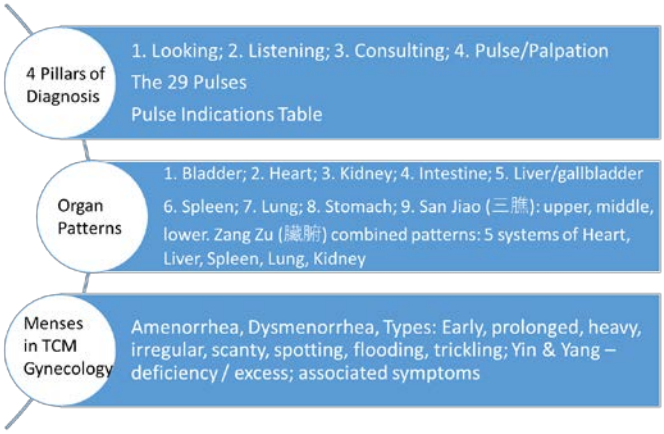

Figure 3: A list of possible sources of diagnostic methods by TCM^2.

As it can be seen in Figure 3, the six evaluation methods in this design only cover a partial list of all the possible diagnostic evaluations, for formulating TCM medical pathways, for the subsequent processes of TCM^{2}DA and TCM^{2}AR. Together with the basic physiological data patterns that can be generated by the standard data collection methods as in Figure 2a, complex and hopefully effective and useful decision paths would be inferred, so that sensible feedbacks could be delivered to the user via the TCM^2 app on a smartphone. It worth mentioning that evaluation methods 1, 2 and 3 involve image analysis from the images photographed by the camera of the smartphone. Evaluation method 4, taps on the built-in microphone on the smartphone. Generally speaking, all the evaluations methods except 5 and 6 are built on existing hardware and firmware from the Android OS and from the smartphone – no special equipment is required. All the syndromes, symptoms, organ patterns and conditions as listed in Figure 3 would be entered as answers to questionnaire by using a Q&A user interface design, this is the Ed part of the TCM^{2}DC.

The functionalities of the six evaluation methods are briefly described as follow. The main challenges are mentioned too.

3.2 Tongue evaluation (Md-Te)

Image processing is the core technique to be applied here for evaluation the condition of a tongue. Tongue diagnosis in TCM for evaluating health is a very comprehensive research topic. The challenge in accurate diagnosis not only goes into the usual information on tongue color, but color and thickness of coating, size and shape of the tongue, features (such as fissures), etc., there are exceptions to the general rules as well. A latest work by researchers from HK Polytechnic University showed it is possible to evaluation tongue condition from TCM perspective using computer vision; the challenge was to control the standards of lighting condition and color calibration [10]. They summarized the characteristics of the salient features of image processing as shown in Figure 4 which is extracted from [10]. The research progress, however, in the view of the authors is limited to two dimensional view in terms of graphics processing. It was mentioned in [10] and other TCM literatures that, it is paramount to observe and detect the cracks on the tongues (patterns, shapes, outlines), and the built-up on tongue coating. These items under detection go beyond only color where the current work was focused on. Our TCM^2 design is to use sophisticated image processing algorithms, plus image modeling and filtering methods which have been published in [11] in hand gesture recognition, for tackling this tongue case. 3D intensity maps could be built for more accurate analysis. Some examples of 3D intensity maps that were built are shown in Figures 5a and 5b.

Figure 4: Salient features of tongue diagnosis.

[3] https://www.sacredlotus.com/go/diagnosis-chinese-medicine

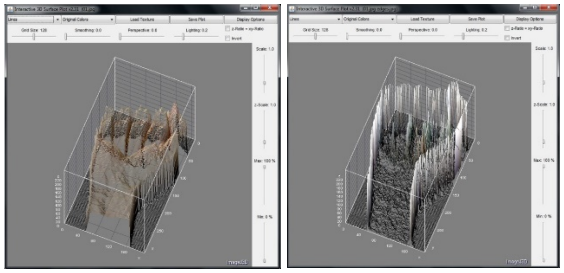

Figure 5: 3D intensity maps from an image of a hand, surface details are seen with Sobel filter applied.

This same technique will be applied in this project for adding extra dimension of information for tongue surface analysis. It is believed that it will work on tongue texture analysis since it has shown to work for human hand as shown in Figures 5a and 5b. The technique has already been tried and proven working as it was published in [11]. Urine color analysis on the other hand, is a simple color saturation comparison versus the cases of known healthy and anomalous samples.

3.3 Voice evaluation (Md-Ve)

For voice evaluation, the task is to record the user's speech without regards of the content; but the duration of the speech record is long enough for the app program to detect for anomalies and assess the quality of the audio information. The voice quality is believed to be reflected from one's health being. A list of salient features that the program looks for is as follow:

The Sound of the Voice

- A loud and course voice indicated an Excess pattern
- A weak and low voice indicates a Deficient pattern
- A lack of desire to speak indicates a Deficient Cold pattern
- Incessant talking indicates a Heat pattern

Hoarse Voice or Loss of Voice

- Acute onset of a hoarse voice is usually indicative of Exterior Pathogenic Wind, especially if the throat is red and sore.
- A chronic or recurrent hoarse voice usually indicates an interior disease such as Deficient Lung Qi or Lung Yin
- A gradual loss of voice also usually indicates Deficient Lung Qi or Yin

Loud Voice with Incoherent Speech

- This is usually accompanied by impaired mental function and indicates Heat is disturbing the Shen (Spirit/Mind)

There have been some progresses that conducted data mining research in voice recognition [6]. The recognition was done without regards to the speech content, but to assess the characteristics of the voice, such as male or female speakers in terms of audio pitch and tones, the mood when the speaker spoke, so to assess the cheerfulness or anger, etc. Such techniques could be extended to assess the voice quality with references to TCM diagnosis. The visualization example is shown in Figure 6.

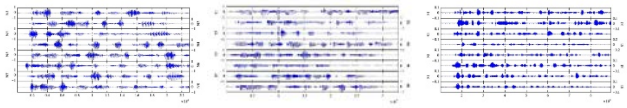

Figure 6: Visualization of voice spoken at moods of (a) happy, (b) neutral, (c) angry.

When it comes to voice analysis, algorithms have been built in the past to distinguish between the different groups or categories of voice tones. In TCM assessment, the same principle applies. Theoretically this can be done easily without much modification from the existing algorithms that were reported in [12]. It is proposed that additional techniques [13] such as those transforming the temporal data from time-series to frequency domain be applied as well, like wavelets. Wavelets provide more information about the characteristics of the voice samples. The challenge however is to further distinguish the categories into a more refined levels. Similar to other TCM assessments which we proposed to evaluate here in this project. A large amount of samples would be required to build a database of common knowledge, which covers every aspect of sample data for machine learning.

3.4 Emotion evaluation (Md-Ee)

Emotional distress can contribute to the development of diseases; this has been known since ancient times in China. According to traditional texts, one can regulate the emotions and reduce their adverse impacts on health by following basic advice such as doing exercise, practicing temperance in eating and drinking, keeping a regular schedule, and pursuing mind-calming activities. A recent publication [4] has reinforced this belief. However, to quantitatively measure stress or emotion is one of the main research challenges in this project.

Emotions or emotional health can be basically measured by Samsung Sleep Sense sleep tracker[5], which can be readily used to extract sleep patterns for analysis. The sleep tracker is designed to fit under a user's mattress and track their sleep, movements and sleep patterns, offering some features based on what it tracks. With the gadget available, the research task is to further refine the pattern analysis according to the TCM principle for assessing and relating one's health by collectively consider sleep patterns, stress levels and general mental states of the user.

To this end, there have been some publications on the similar works in analyzing EEG brainwave patterns in the past, mostly by using machine learning techniques in distinguishing different states of brainwaves. Examples of normal and abnormal brain waves in the format of EEG are shown in Figure 7, as done from the past work [14]. The main challenge in this aspect is to remodel the machine learning models so to be able to recognize different moods and relate different mood patterns to different TCM concepts, by extending the work done in [14] from binary classification to multi-class classification.

[4] http://www.itmonline.org/arts/emotions.htm
[5] http://www.techtimes.com/articles/81353/20150903/samsung-sleep-sense-tracker-ho-hum-thats-it-for-ifa-2015.htm

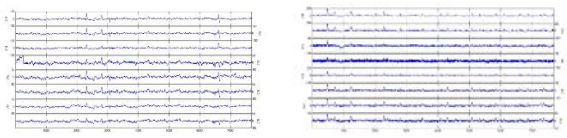

Figure 7: Examples of EEG brainwaves automatically recognized into two groups.

3.5 Pulse evaluation (Md-Pe)

In Western medicine, the pulse is only a minor diagnostic tool, it is, however, very important in TCM. Pulse diagnosis gives information on: 1. The state of balance of the body as a whole, i.e. the state of the Qi, Blood, Yin and Yang, and even the constitution. 2. The state of individual Organs (esp. Yin Organs).

TCM practitioners feel the pulse and note the rate. They discern width or amplitude, length, how close it is to the surface, how deep and close to the bone, the strength, and other qualities. Without going too deep into this topic which is very large in extents, an external gadget called Meridian Health Analyzer is to be acquired and used. The focus of this framework is not to study in depth about the efficacy of this technological measuring machine. But rather, the idea is to use it as a data collection instrument, and from the collected data, we infer decision rules and build a recommender as an all-in-one integrated mobile app for convenient use. The meridian analyzer we intend to acquire is similar to the model[6] as shown in Figure 8a. It is however an external device, interfacing with a computer by USB connection. This external devise will be treated as other external accessories which interface with Samsung Android OS, a list of which is briefly shown in Figures 8b and 8c. The task here is to interface the meridian analyzer with the Mobile app, collect data, analyze and facilitate the whole monitoring framework TCM^2.

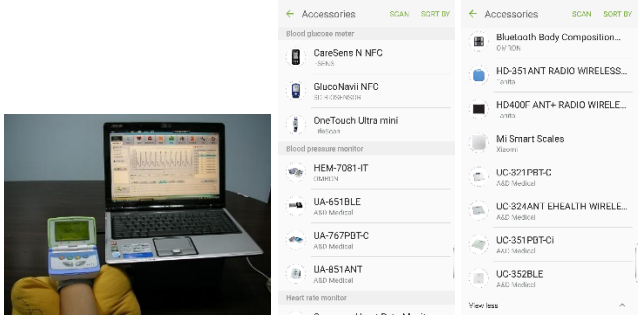

Figure 8: Meridian Health Analyzer, and possibilities of integrating external devices.

3.6 Data Analysis TCM^{2}DA

When the bio-data have been connected and readily collected into the app, the data analysis functions would have to be operational too. In the TCM^2 design, the system architecture will be client-server based. Two remote data storages would be used, one for feeding contents of the app and intelligent recommender feedbacks, which are shown in the top corner of Figure 9 within some enterprise premise. The bio-data that are continuously collected from the users would be stored securely in the cloud accounts, on a cloud server as indicated at the lower corner of Figure 9. The bio-data of each individual user would be synced up with the intelligent recommender, and the data would be analyzed online, away from the computing perimeter of the mobile app, so to save battery life and reduce computing consumption on the local client. The app will be mainly used for interacting with the users' commands, interface for data collection, and feedback plus monitoring functions.

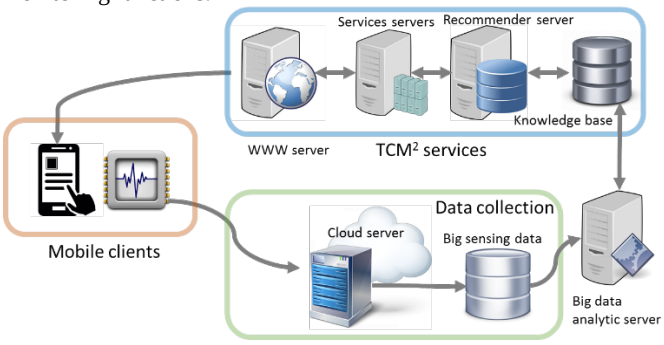

Figure 9: Two tier remote storage design for TCM^2 app.

The data analysis consist of two types of functions: supervised learning models and unsupervised models. The first type attempts to build a "model" that maps the underlying relations between the input attributes that characterize certain bio-patterns and some predefined class labels, based on historical records. Classification and prediction (depending on whether a labelled verdict or numeric value is to be output) are common functions derived from the model. Figure 10 shows a typical classification model that embrace historical input data, for inferring a classification model. Subsequently decision rules can be derived further from the induced classification model. Options of traditional data mining and data stream mining algorithms could be employed for this task.

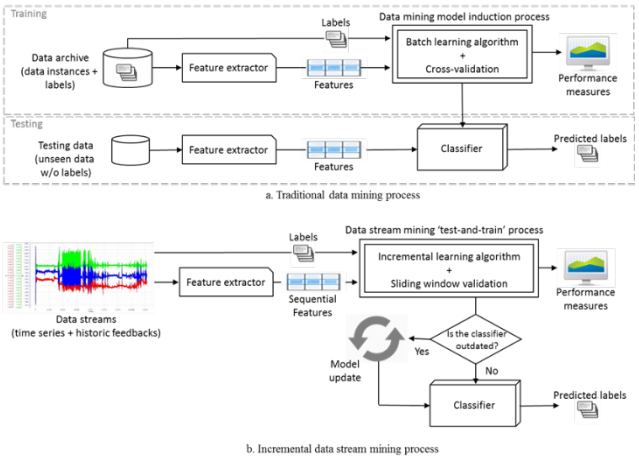

Figure 10: Traditional data mining process versus incremental data stream mining process.

With a case of diabetes therapy which is similar to the TCM case proposed in this project, the feasibility of applying data

[6] http://answatch.ktop.com.tw/?id=2169#pgo

stream mining in monitoring health with a mix of intervened factors has been studied and published [15]. Many machine learning algorithms are possible candidates for this type of application scenarios, such as neural network, decision tree, SVM and a new breed of incremental fast learner aka data stream mining algorithms. Once a model is established, Bump Hunting algorithm or similar, such as Fuzzy Unordered Rule Induction could be used to generate decision rules. For the case of diabetes therapy management, the input data which are multi-variate data stream feeds (similar to what TCM^2 collects) and the performance evaluation of the most accurate data stream mining algorithms are shown as illustrating proof of concept in Figure 11.

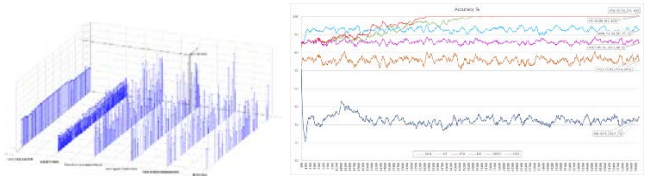

Figure 11: Input data visualized, performance evaluation of different data stream mining algorithms.

The decision rules harvested from the model would be used for recommender, which is designed as the component auto-recommender (TCM^{2}AR) in the project. Some sample outputs are shown in Figure 12. On the other hand, time-series matching belongs to the supervised learning research tasks.

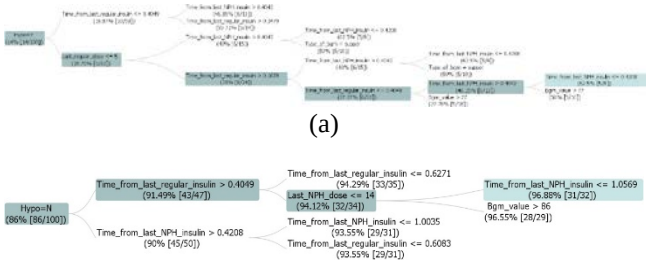

Figure 12: Decision rules generated by Bump Hunting that describe (a) Hypo = Yes and (b) Hypo = No.

Mainly in this TCM related projects we need to match, compare and discover new sub-patterns from patterns, by using some efficient and effective means. In the past years, some works have progressed with inventing a number of advanced algorithms towards this research goal. They are namely, NSPRING [16], Normalized Cross-Matching [17], Fuzzy subsequence Discovery and UCR-DTW-extended pattern matching suites. They would be used in this project because TCM^2 mainly will be dealing with sequential time-series patterns of longitudinal activities, food intake, sleep patterns, EEG, ECG, bio-signals etc. They may come in patterns with certain special characteristics e.g. stress, signs of diseases, or anomalies; however, each person will not have exactly the same patterns. Such normalized and fuzzy matching algorithms are highly needed in this project. Example is given in Figure 13 where a unique but not exact shape of sub-sequence is to be discovered from the main sequence.

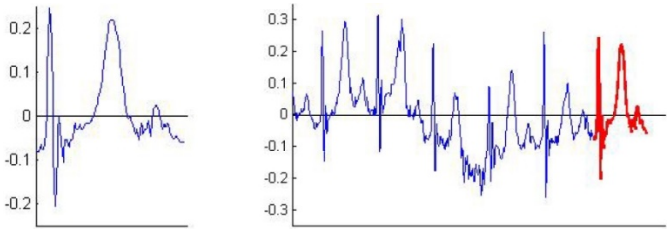

Figure 13: Example that illustrates a sub-pattern is embedded in main pattern in pattern discovery.

4 CONCLUSIONS

Aging is a global problem, particularly it is expected to be severe in China due to the one-child policy. Traditional Chinese Medicine has the principles of prevention before cure; many written doctrines and practices have been around for decades. Lately such healthcare principles, focus on caring one's health by longitudinal monitoring, analyzing and taken care of, by expert systems via an array of sensing and machine learning technologies are materialized. Specifically, the underlying and supporting algorithms, hardware and software technologies are mostly available for implementing this TCM^2 project as reviewed in this paper. The main work, in the technical aspects, is to find, to modify, to enhance and fine-tune the most suitable configuration and applications of those algorithms and software/hardware for the use of TCM healthcare monitor and therapy. Without starting everything from scratch, the latest of arts progressed by recent research momentums will be tested, polished and enlisted as building blocks for constructing TCM^2 apps and its related cloud server architecture behind. Another main challenge is to steer and shape the I.T. research efforts in very close alignment with the domain knowledge of TCM. The success of this project hinges very much on the close collaboration of the computer science research team and the TCM knowledge practitioners. Under the proposed research framework as described in this paper, the TCM^2 pilot project is positioned as a general healthcare personal advisor mobile app. However, it could be extended in the future that could be used as specific prognosis aid for patients who are already ill, needing this technology as reminder and guidance in recovery. Two application cases: General cases (GC), sick cases (or clinical cases) GC = never have an illness, maintain, measure, predict if ever will get an illness or stay healthy SC = ever known to have an illness - used to be sick, now recovered, predict if and when will be sick again. If the status is currently sick, it predicts if and when will recover soon. As future works, this paper can serve as a blue-print, the individual research components as described in Section 3 should be tested and pieced together for realizing a full vision of ubiquitous healthcare system embracing health, countering aging, lowering health risks, using what the technologies are currently available.

ACKNOWLEDGMENTS

The authors are thankful for the financial support from the Research Grant titled: "Temporal Data Stream Mining by Using Incrementally Optimized Very Fast Decision Forest (iOVFDF)", Grant no. MYRG2015-00128-FST, offered by the University of Macau, FST, and RDAO.

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