

國立交通大學

資訊管理研究所

碩士論文

一個無所不在的情境感知式健康照護系統之設計與實作

The Design and Implementation of a Ubiquitous Context-aware  
Healthcare Service System



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中華民國九十八年六月

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## 摘要

近年來，隨著經濟成長、人民生活水準的提高、醫學藥物進步，民眾的平均年齡已顯著的延長，銀髮族、樂活族(Lifestyles Of Health And Sustainability, LOHAS)人口逐漸增加，而國人疾病型態及死亡原因，也由原來的急性傳染病和急性疾病，轉變成慢性疾病，如心臟病、糖尿病、高血壓等。

本論文有鑑於觀光醫療和自然療法的未來需要，提出一個無所不在的情境感知式健康照護系統之設計與實作(Ubiquitous Context-aware Healthcare Service System, UCHS)，主要包含有情境感知式觀光醫療服務搜尋子系統(Situation-Aware Medical Tourism Service Search Subsystem, SAMTS<sup>3</sup>)、養生地圖導覽子系統(Healthy-life Map Guiding Subsystem, HMGS)、智慧型飲食治療服務決策支援子系統(Intelligent Curative Food Decision Support Subsystem, ICFDSS)、4D路徑緊急醫療救護指派子系統(4D Emergency Indication and Ambulance Dispatch Subsystem, 4DEIADS)，以提供一套整合的自然療法服務平台。此系統結合專家的醫療知識，同時考量各個療法對病症的正向影響和負向影響，並搭配語意網架構推論使用者的病徵，經研究實驗證明可有效且快速地推薦給使用者一個合適的自然療法綜合資訊服務，讓使用者可以達到吃喝玩樂享健康的願景。

關鍵字：觀光醫療、養生地圖、飲食治療、緊急救護、決策支援系統、資訊檢索、自動摘要

# **The Design and Implementation of a Ubiquitous Context-aware Healthcare Service System**

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## **Abstract**

The rise of the quality of life index together with the improvement of medical technology lead to a longer life expectancy. Thus a better health care program, especially for elderly, is needed. The common health problems facing those senior citizens are changed from acute diseases to chronic diseases, such as diabetes, hypertension, and etc. Along with these changes, medical tourism is becoming the trend of the future.

In this paper, we propose a decision support systems, the Ubiquitous Context-aware Healthcare Service System (UCHS), which uses micro sensors integrate RFID to sense user's life vital signal, such as electrocardiogram (ECG/EKG), heart rate (HR), respiratory rate (RR), blood pressure (BP), blood sugar (BS), and temperature and light. The UCHS is composed of Situation-Aware Medical Tourism Service Search Subsystem (SAMTS<sup>3</sup>), Healthy-life Map Guiding Subsystem (HMGS), Intelligent Curative Food Decision Support Subsystem (ICFDSS), and 4D Emergency Indication and Ambulance Dispatch Subsystem (4DEIADS) to provide relevant nature medicine recommendations to its user. The UCHS built upon an integrated service platform in which medical experts' knowledge and all position and negative influence of the proposed therapy are inferred by using semantic network.

Keyword: Medical Tourism, Health-life Guiding, Curative Food, Emergency Medical, Decision Support System, Information Retrieval, Text Summarization.

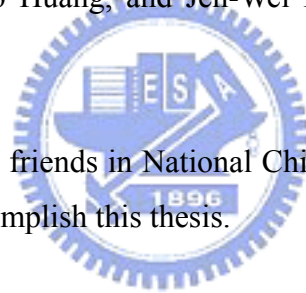
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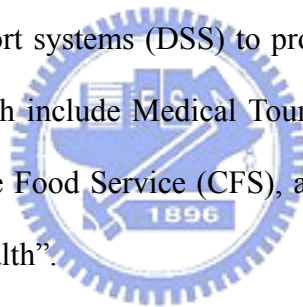
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# Chapter 1 Introduction

## 1.1 Research Background and Motivation

Recently medical tourism is becoming more popular, as more people realize its benefits. The main benefits of health tourism include getting the opportunity to travel to an exotic destination and reaping potentially big monetary savings [46]. In “Industrial Manpower Package for Three-year Head-start Project of Taiwan’s Economic Development Visions for 2015” [19], Ubiquitous Healthcare (U-Health) is meant it has more commercial potential in taiwan in the future. Therefore, Taiwan Medical Tourism Development Association (TMTDA) was established to research and hold relevant medical tourism activities in August 2007. However, to date, there are only a few decision support systems (DSS) to provide Nature Medicine Services (NMS) recommendation which include Medical Tourism Service (MTS), Health-life Map Service (HMS), Curative Food Service (CFS), and etc. to reach the target “Eat, Drink, and Be Merry with Health”.



Recently there have been many developments on recommendation model in other domains for the semantic web which is an opportune moment to look at the field’s current state and future opportunities. For inference user’s requirement to recommend, the semantic web possibly combines Service-Oriented Architecture (SOA, includes UDDI (Universal Description, Discovery and Integration), SOAP (Simple Object Access Protocol), WSDL (Web Services Description Language)) with RDF (Resource Description Framework), DAML (DARPA Agent Markup Language), DAML-S, DAML+OIL, OWL (Web Ontology Language), OWL-S, or etc. [14, 49, 75].

The need for NMS recommend in semantic web is driven by three demands.

- (i) To inference user’s requirements by semantic engine.

(ii) To search, compare, reorganize, and integrate relevant web services to be medical tourism service according to medical domain knowledges.

(iii) To reduce query processes and time.

## **1.2 Approach and Result**

This paper provides an overview of the medical tourism service recommend in semantic web, combines the technical application of the SOA, OWL-S, semantic web on information system, the system gives strong auxiliary utility to support users while they have some complex problem. The designed Ubiquitous Context-aware Healthcare Service System (UCHS) is composed of Situation-Aware Medical Tourism Service Search Subsystem (SAMTS<sup>3</sup>), Healthy-life Map Guiding Subsystem (HMGS), Intelligent Curative Food Decision Support Subsystem (ICFDSS), and 4D Emergency Indication and Ambulance Dispatch Subsystem (4DEIADS) to provide relevant nature medicine recommendations to its user [5, 6, 7, 8, 24]. Using SOA, OWL-S to build semantic web environment to inference user's requirements and search various web services which are published in UDDI through the communication networks include internet and 3G/GPRS/GSM mobile networks [2, 13]. In this paper, we propose the specific Medical Stemming Mechanism (MSM) and Medical Ontologies (MOs) using OWL-S combined Adaptive Medical Service Inference Module (AMSIM) which is composed of Term Frequency – Inverse Document Frequency (TF-IDF), Latent Semantic Analysis (LSA), and k-Nearest Neighbor (kNN) to reference the adaptable NMS to MUs.

## **1.3 Thesis Outline**

The remainder of the thesis is built as follows. In Chapter 2, we provide background knowledge through the description of related technologies, such as the

concept of Semantic Web (SW), Requirement Classification Techniques, Multiple Document Summarization (MDS), and Context-aware, and the discussion about the current methods for NMS searching. In Chapter 3, we proposed the Ubiquitous Context-aware Healthcare Service System (UCHS) combined semantic inference and context-aware technique to provide NMS. The framework which is composed of Situation-Aware Medical Tourism Service Search Subsystem (SAMTS<sup>3</sup>), Healthy-life Map Guiding Subsystem (HMGS), Intelligent Curative Food Decision Support Subsystem (ICFDSS), and 4D Emergency Indication and Ambulance Dispatch Subsystem (4DEIADS) is explained in Chapter 4~7. Finally conclusion and the suggestions are given in Chapter 8.



## Chapter 2 Related Works

The Designed Ubiquitous Context-aware Healthcare Service System (UCHS) is to provide (i) user's requirement inference, (ii) Nature Medicine Services (NMS) decision support, (iii) searching and inference performance. Necessary research background and relevant technology include as follows: (1) Semantic Web (SW), (2) Requirement Classification Techniques, (3) Multiple Document Summarization (MDS), and (4) Context-aware.

### 2.1 Semantic Web (SW)

To solve the problem of lacking effective service query mechanism in existing web services, a SW based technology based web services query mechanism was proposed by Tim Berners-Lee whose proposed vision [60] is shown as Fig. 1.

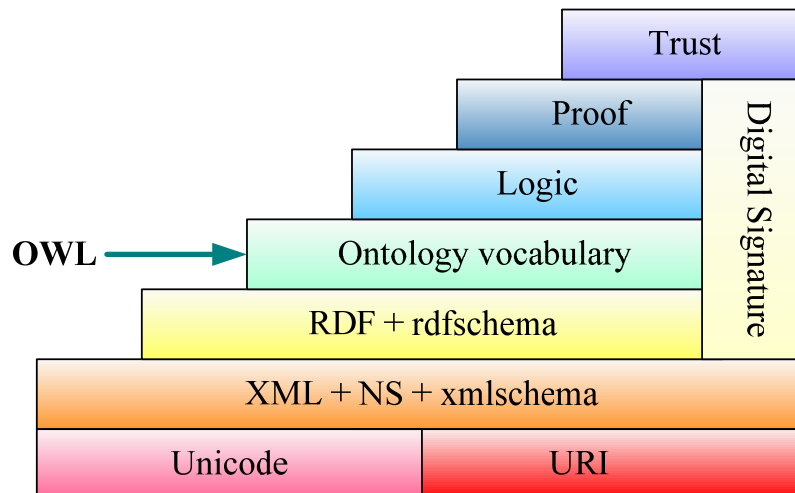


Figure. 1. Semantic Web Stack [60]

In this paper, we focus on (1) semantic inference and (2) system performance de-scribed as follow.

### **2.1.1 Semantic Inference**

For inference user's requirement semantically, Ora Lassila and James Hendler [49] proposed a architecture of SW applications based on RDF, with patterns in which one component uses another as a data source (via SPARQL) and acts as a data source to yet another component. However, RDF and RDF schema provide properties and syntax not completely to build ontology architecture. In this paper, we use the OWL-S which is an OWL-based Web service ontology that supplies web service providers with a core set of markup language constructs for describing the properties and capabilities of Web services in unambiguous, computer-interpretable form.

### **2.1.2 System Performance**

For efficient selection of QoS-aware web service, in reference [42], we can know the inquiry API of JUDDI has better performance than JWSDP (Java Web Services Development Pack). And there were some approaches proposed by reference [44, 68], which used "cache" mechanism for reducing process and queries while service broker inferences QoS-aware web services. Therefore, we choice JUDDI to build UCHS with "cache" mechanism to provide SW services.

## **2.2 Requirement Classification Techniques**

To date, there are various requirement classification systems which are proposed and implemented. In general, those systems consist of the following steps: (1) Preprocessing, (2) Constructing a set of centroid-sentences as training data for each topic category, and (3) Learning classifier [72].

The main roles of preprocessing are (i) segmenting requirements into sentences and (ii) extracting content word [72]. For Chinese, the CKIP group develops the Chinese segmentation system which includes the methods for resolving unknown



words [66] is very useful. Although, these approaches are serviceable, they have lower power for special domain such as medical tourism in this case. For example, the sentence “皮膚有類症” which there are four segments “皮膚(Na)”, “有(V\_2)”, “類(Nf)”, and “症(Na)” of is a specific technicality.

In step (2), it focus on (i) generating a keyword list for each category, (ii) extracting keyword sentences, and (iii) measuring word and sentence similarities [72]. For measuring similarities, there are two kinds of approaches proposed which are corpus-based semantic similarity (CBSS) and ontology-based semantic similarity (OBSS). The basic idea of CBSS is the similarity of two words  $w_1$  and  $w_2$  can be calculated through the two distributions  $P(C | w_1)$  and  $P(C | w_2)$ , where  $C$  is the union of the  $w_1$  and  $w_2$  context features, which in the simplest form would be words that co-occur in a corpus with  $w_1$  and  $w_2$  [31]. However, CBSS can't support to semantically classify ontological concepts, but OBSS. In this paper, UCHS will apply OBSS to use the hierarchy of the ontology to calculate the distance between two concepts.

For classifier, there are many kinds of classification techniques such as k-Nearest Neighbor (kNN) [48], clustering, and association rule. In [48], Naohiro et al. propose a new combining method which for consists of Latent Semantic Analysis (LSA) followed by the kNN the documents classification. Although, this result of combining method is the higher accuracy, the method only considers with the positive influence factors. We will consider the positive and negative influence factors to improve the inference algorithm.

### 2.3 Multiple Document Summarization (MDS)

Blogs increase greatly in recent years because of the rapid development of computer technology and the spread of internet. Users may get a huge amount of

information through the intelligent agency from the blogs. However, it's not easy to filter the useless and repeated information for the users. To solve this problem, MMESP use the Multiple Document summarization (MDS) to simplify and get rid of the repeated information, so the users can save the searching time and get the important information.

UCHS is combined with MEAD which is a public domain portable multi-document summarization system based on Linux. MEAD whose process is shown as Fig. 2 is implemented by Perl programming language [18].

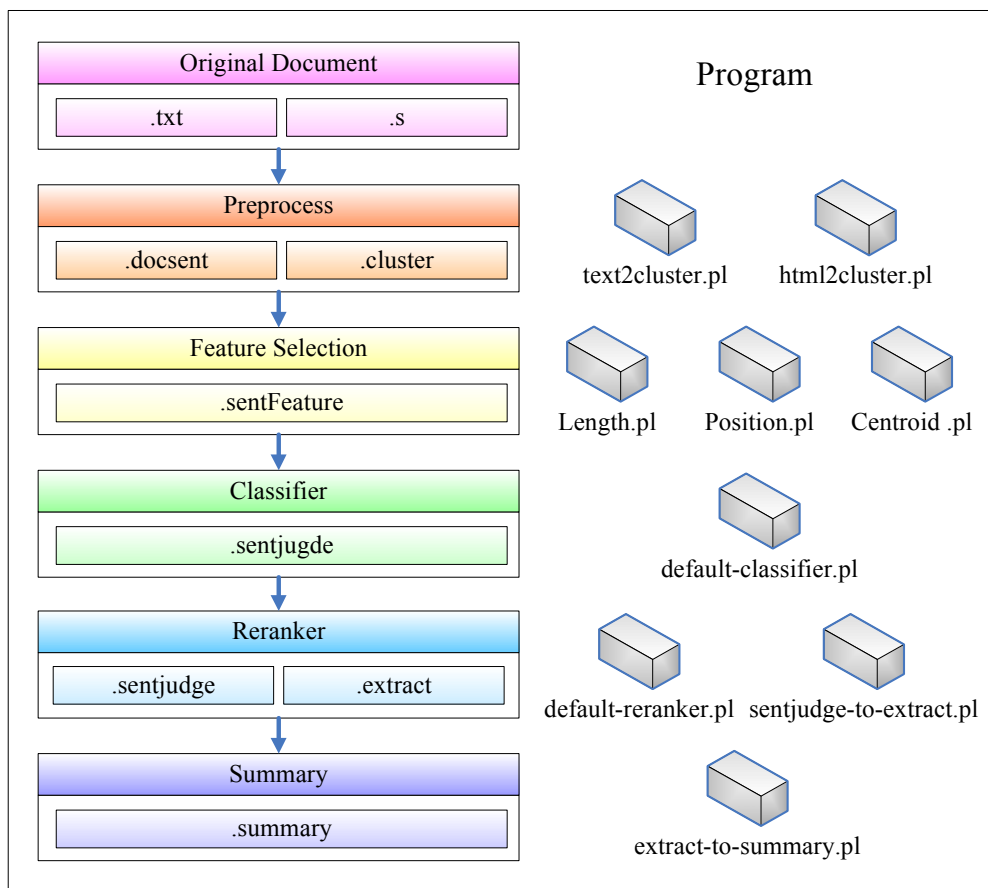


Figure. 2. The process of MEAD

The main procedures of MEAD are shown as follow.

### **(1) Preprocess**

The intelligent agent to retrieve the contents of the Blog using HTML format to segment the sentences in original document in order to facilitate follow-up to the weight computing [9, 10, 11].

### **(2) Feature Selection**

In this paper, MDS is designed to consider several features to compute the weight of each sentence by words and phrases. The main three features are centrality, sentence length, and position [4, 15, 16, 33, 34].

### **(3) Classifier**

The scores of every sentence are mainly computed through the weight with each feature [37].



### **(4) Reranker**

Because by the Classifier is only carried out in accordance with score of sentence similarity calculation and sorting. It makes the problem that may exist the high similarity between sentences, especially in multi-document summarization. MEAD designs Reranker mechanism to recalculate the sentence with the syntactic similarity and set the threshold to filter out important sentences to reduce the redundancy ratio. Finally, the summary is made by extracting the sentences from original document by the compression ratio [20].

## **(5) Summarization**

Summarization can retrieve and recombine words and phrases in the original document according to the order of the sentences by Reranker sorting.

## **(6) Evaluation**

HMGS is used to measure the performance of text summarization system including the effect of output results as well as users' satisfaction [54].

## **2.4 Context-aware**

Context awareness is the important interactive system. Researchers add appropriateness and keep with user's requirement in the system. Dey et al [1] defined that "context is any information that can be used to characterize the situation of an entity. An entity is a person, place or object that is considered relevant to the interaction between a user and an application, including the user and applications themselves [1]". Dey et al classify location, identity, time, and activity according to context-awareness.

In the above, context-awareness for the concept of location services of the extension service, the parameters take advantage sensors sensing user around environment. The system provides the adaptive services where users are in different environment [1, 23].

## Chapter 3 Ubiquitous Context-aware Healthcare Service

### System (UCHS)

For reaching the target “Eat, Drink, and Be Merry with Health”, this paper provides an overview of the Nature Medical Service (NMS) recommend in semantic web, combines the technical application of the SOA, OWL-S, semantic web on information system, the system gives strong auxiliary utility to support users while they have some complex problem. The designed Ubiquitous Context-aware Healthcare Service System (UCHS) is composed of Situation-Aware Medical Tourism Service Search Subsystem (SAMTS<sup>3</sup>), Healthy-life Map Guiding Subsystem (HMGS), Intelligent Curative Food Decision Support Subsystem (ICFDSS), and 4D Emergency Indication and Ambulance Dispatch Subsystem (4DEIADS) to provide relevant nature medicine recommendations to its user [5, 6, 7, 8, 24].



### 3.1 Overview

The architecture of Ubiquitous Context-aware Healthcare Service System (UCHS) which is composed of SAMTS<sup>3</sup>, HMGS, ICFDSS, and 4DEIADS enhances Mobile Users (MUs), Mobile Medical Monitor (M<sup>3</sup>), External Resource (ER), UDDI Registries (UDDIRs), Nature Medical Service Providers (NMSPs), and Database Server (DS) shown as Fig. 3.

MUs can utilize various terminal devices that include Personal Computer (PC), notebook, Tablet PC, Personal Digital Assistant (PDA), and smart phone to access UCHS to get adaptable NMS. Moreover, MUs will use M<sup>3</sup> combined micro sensors to immediately sense user's life vital signal, such as electrocardiogram (ECG/EKG), heart rate (HR), respiratory rate (RR), blood pressure (BP), blood sugar (BS),

temperature, and light parameters. Those records will be transmitted and stored in DS for inference by SAMTS<sup>3</sup>, HMGS, ICFDSS, and 4DEIADS [5, 6, 7, 8, 24].

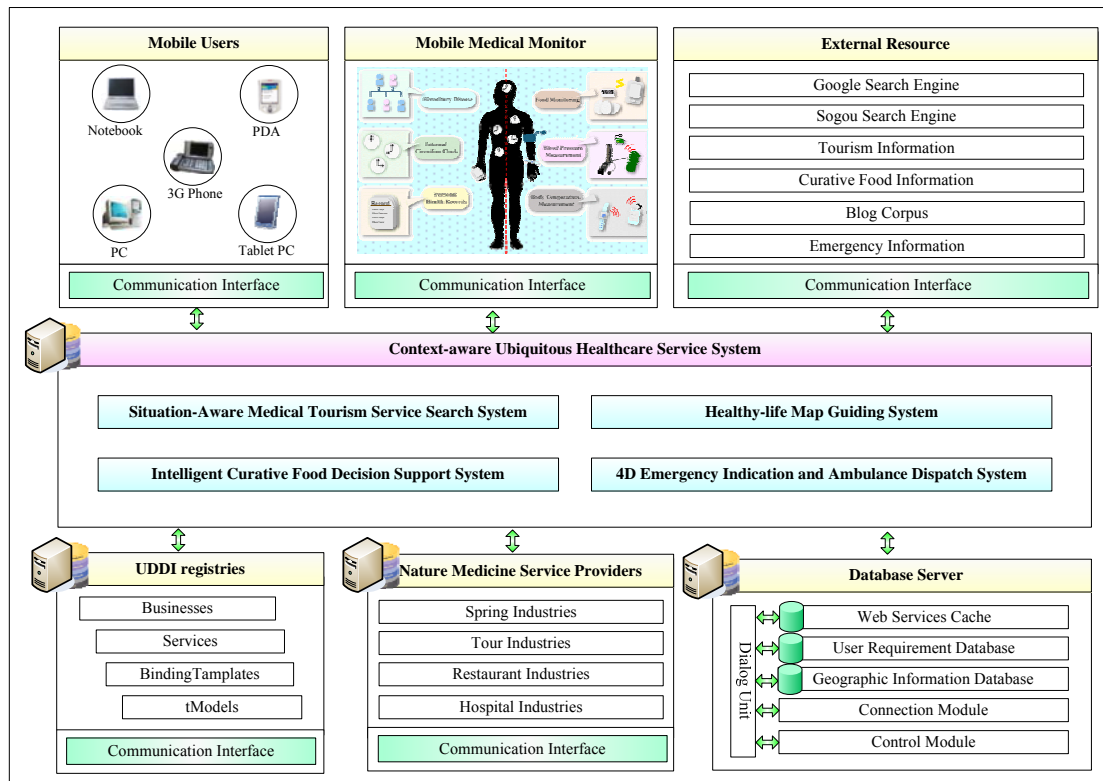


Figure. 3. The architecture of Ubiquitous Context-aware Healthcare Service System (UCHS)

The aim of semantic web is to locate services automatically based on the functionalities Web services provide. UDDI is helpful to discovery web services with semantic web. Therefore, we use the JUDDI to build UDDI environment which provides Business Entities, Service Entities, Binding Templates, and tModels to represent the detail of business and its services.

In this paper, NMSPs which can publish the NMS to UDDIRs through heterogeneous networks are Spring Industries, Tour Industries, Curative Food Industries, Hospital Industries, and etc. NMSPs will provide the order ticket service, reservation service, tourism information service, and emergency information service, and etc.

MUs use mobile device to request their medical requirements to UCHS, in order to carry on the inference of NMS by SAMTS<sup>3</sup>, HMGS, ICFDSS, and 4DEIADS. In this paper, UCHS will provide the adaptable package tour services to reach the target “Eat, Drink, and Be Merry with Health” for MUs. First, SAMTS<sup>3</sup> will provide the adaptable Medical Tourism Service (MTS) by inference the MUs’ medical requirement and their history health records. HMGS will provide relevant tourism information and tourist experience summary according to the adaptable MTS. Finally, ICFDSS will provide the adaptable Curative Food Service (CFS) and reservation automatically by inference the MUs’ medical requirement and MTS. On the other hand, UCHS also combines the 4DEIADS to provide Emergency Medical Service (EMS) when accident happened. UCHS will query and invoke the NMS from UDDIRs, NMSPs, and External Resource (ER) frequently to provide the adaptable NMS. The introduction of SAMTS<sup>3</sup>, HMGS, ICFDSS, and 4DEIADS will be discussed as following.



### **3.2 Situation-Aware Medical Tourism Service Search Subsystem (SAMTS<sup>3</sup>)**

Recently medical tourism is becoming more popular, as more people realize its benefits. The main benefits of health tourism include getting the opportunity to travel to an exotic destination and reaping potentially big monetary savings [46]. Therefore, Taiwan Medical Tourism Development Association (TMTDA) was established to research and hold relevant medical tourism activities in August 2007.

In this paper, we propose a new Medical Tourism Service (MTS) recommend system, the designed Situation-Aware Medical Tourism Service Search Subsystem (SAMTS<sup>3</sup>), which provides the cooperation web-based platform for all related Mobile Users (MUs) and Medical Tourism Service Providers (MTSPs) could strengthen the

ability of MTS suggestion. SAMTS<sup>3</sup> is a five-tier system composed of the MUs, UDDI Registries (UDDIRs), MTSPs, Medical Tourism Services Server (MTSS), and Database Server (DS). Using SOA, OWL-S to build semantic web environment to inference user's medical requirements and search adaptive MTS and web services which are published in UDDI through the communication networks include internet and 3G/GPRS/GSM mobile networks. In this paper, we propose the specific Medical Tourism Stemming Mechanism (MTSM), Medical Ontology (MO), and Adaptive Medical Tourism Inference Module (AMTIM) combined Term Frequency – Inversed Document Frequency (TF - IDF), Latent Semantic Analysis (LSA), and k-Nearest Neighbor (kNN) to reference the adaptable MTS to MUs [7, 8]. The detailed design and analysis of SAMTS<sup>3</sup> will be discussed in chapter 4.

### **3.3 Healthy-life Map Guiding Subsystem (HMGS)**

The rise of the quality of life index together with the improvement of economic growth lead to increase tourism requirements. Recently tourism which is becoming more popular has become a current hot topic. In addition, as people on the popularity of the concept of Healthy-Life, making more and more people increasingly attach importance to good health and enjoy Healthy-Life services. Healthy-Life tourism services are the trend of the future.

In this paper, we propose an effective decision support system (DSS), the Healthy-life Map Guiding Subsystem (HMGS), which provides the introduction and commentaries of Healthy-Life scenic spots with relevant recommendation. HMGS is a three-tier system composed of the Clients, Multimedia Application Server (MAS), and Database Server (DS) to provide the introduction and commentaries of Healthy-Life scenic spots with relevant recommendation. HMGS is combined with an automatic text summarization technology to provide summary of commentaries. Finally, HMGS



provides the adaptable tourism path in 3D web geographic information system for user reaching the Healthy-Life scenic spots [5]. The detailed design and analysis of HMGS will be discussed in chapter 5.

### **3.4 Intelligent Curative Food Decision Support Subsystem (ICFDSS)**

Recently curative food is becoming more popular, as more people realize its benefits. Based on the theory of Chinese medicine, food itself is medicine. The curative food which is an ideal nutritious food can help to loss weight, increase immunity and is also good for curative effects in patients. While economy and health concept are raises, most food full on markets. How uses food to preserve people's health is a popular topic.

In this paper, we proposed and developed the “Intelligent Curative Food Decision Support Subsystem (ICFDSS)” to record efficiently user’s diet. Using micro sensors integrate RFID to sense user’s life vital signal, such as electrocardiogram (ECG/EKG), heart rate (HR), respiratory rate (RR), blood pressure (BP), blood sugar (BS), and treatment and light. ICFDSS provides the cooperation web-based platform for all related Mobile Users (MUs) and Curative Food Service Providers (CFSPs), could strengthen the ability of CFS suggestion. SCFSRS is a five-tier system composed of the MUs, UDDI Registries (UDDIRs), CFSPs, Curative Food Services Server (CFSS), and Database Server (DS). On the other hand, ICFDSS achieves balance diet that can provide diet exhorting and suggestion by Medical Ontology, Latent Semantic Analysis, and k-Nearest Neighbor etc [6]. The detailed design and analysis of ICFDSS will be discussed in chapter 6.

### **3.5 4D Emergency Indication and Ambulance Dispatch Subsystem (4DEIADS)**

When the heavy rainfalls or typhoons occurred, many counties were unavoidable to suffer the debris-flow and flood disasters in Taiwan. Therefore, it is urgently required to obtain and inform the real-time disaster information to display the situation, and it is important for people to design an effective disaster information system to assist the disaster protection and alerting works.

To plan and design a 4D Emergency Indication and Ambulance Dispatch Subsystem (4DEIADS), which is a three-tier system composed of the mobile users, multimedia server, and disaster decision server, and the system combines mobile communication technology. 4DEIADS combines RFID technology, GPS, GIS and GPRS/3G to find out the 4D safety paths and roads in the disaster areas, and the disaster decision is packed as a reusable web services which can be used in 4DEIADS or other systems for reducing the cost and speeding up the efficiency of system development in the future. Mobile users use mobile devices with GPS to locate the longitude and latitude, and transmitting these coordinates to the GIS server. According to the longitude and latitude, the GIS will draw VR map of disaster area using GIS relevant database and show the simulated safety way to users. The 4DEIADS can draw the points on the VR map that includes all users' position and announces the best refuge and escape path. The reasoning engine of 4DEIADS is used Knapsack Problem (KP) and the Adaptive Path Algorithm (APA) which consider distance, security, traffic volume, cost, and refuges where RFID readers were installed to infer reason the 4D safety paths and escape routes [24]. The detailed design and analysis of 4DEIADS will be discussed in chapter 7.

## **Chapter 4 Situation-Aware Medical Tourism Service Search**

### **Subsystem (SAMTS<sup>3</sup>)**

In this paper, we propose a new Medical Tourism Service (MTS) recommend system, the designed Situation-Aware Medical Tourism Service Search Subsystem (SAMTS<sup>3</sup>), which provides the cooperation web-based platform for all related Mobile Users (MUs) and Medical Tourism Service Providers (MTSPs), could strengthen the ability of MTS suggestion. SAMTS<sup>3</sup> is a five-tier system composed of the MUs, UDDI Registries (UDDIRs), MTSPs, Medical Tourism Services Server (MTSS), and Database Server (DS). Using SOA, OWL-S to build semantic web environment to inference user's medical requirements and search adaptive MTS and web services which are published in UDDI through the communication networks include internet and 3G/GPRS/GSM mobile networks. In this paper, we propose the specific Medical Tourism Stemming Mechanism (MTSM), Medical Ontology (MO), and Adaptive Medical Tourism Inference Module (AMTIM) combined Term Frequency – Inversed Document Frequency (TF - IDF), Latent Semantic Analysis (LSA), and k-Nearest Neighbor (kNN) to reference the adaptable MTS to MUs [7, 8].

#### **4.1 System Design Principles**

The Situation-Aware Medical Tourism Service Search Subsystem (SAMTS<sup>3</sup>) provides Semantic Inference Module (SI) and Adaptive Medical Tourism Service Inference Module (AMTSIM). The SIM is combined specific Medical Tourism Stemming Mechanism (MTSM), Medical Ontology (MO), and OWL-S standard to inference and translate the original sentences to be machine readable. And the

AMTSIM uses the TF - IDF, LSA, and kNN to calculate the similarity and inference the adaptive MTS.

### 4.1.1 Semantic Inference Module (SIM)

The Semantic Inference Module (SIM) exploits MTSM and MO to explain and to represent the data of expert's suggestions and user's requirement shown as Fig. 4.

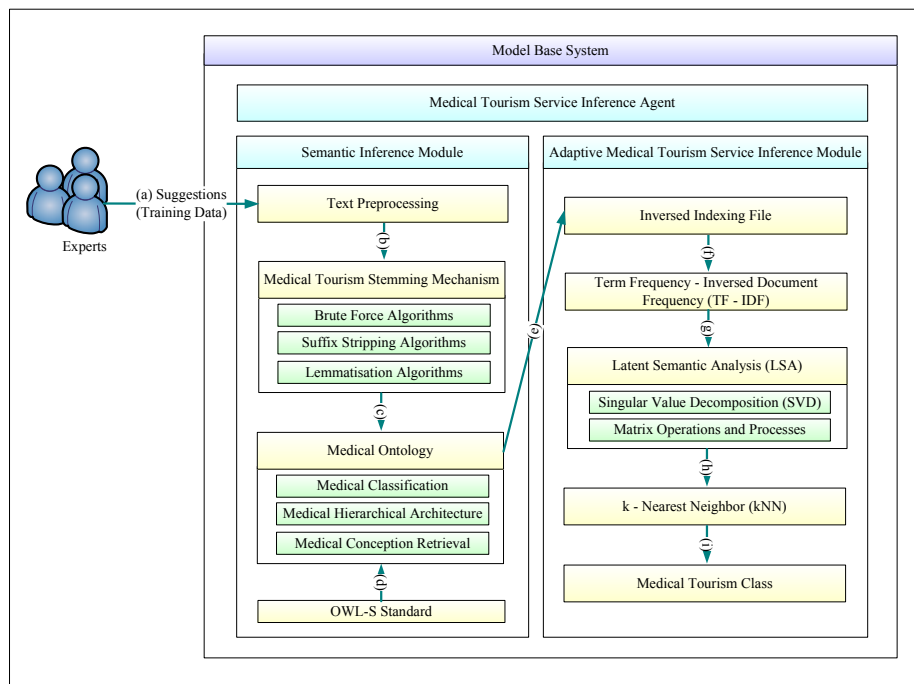


Figure. 4. Medical tourism knowledge training process

#### 4.1.1.1 Preprocess

Preprocess translate the different expert's suggestions and user's requirements to be the vector space model. During training time, the collection of therapy suggestions (an example is shown as Fig. 5.) as a set of documents will be represented by a word-by-document matrix  $A_1$  and  $A_2$ , where each entry represents the occurrences of a

infirmity as a word in a document, i.e.  $A_I = \{af_{in} \mid i \in I, n \in N\}$ , where  $af_{in}$  is the frequency of the infirmity  $i$  in the therapy  $n$ . Let  $I$  be the number of the occurrence of all the infirmities in those therapies and  $N$  be the number of the occurrence of all the collected therapies.

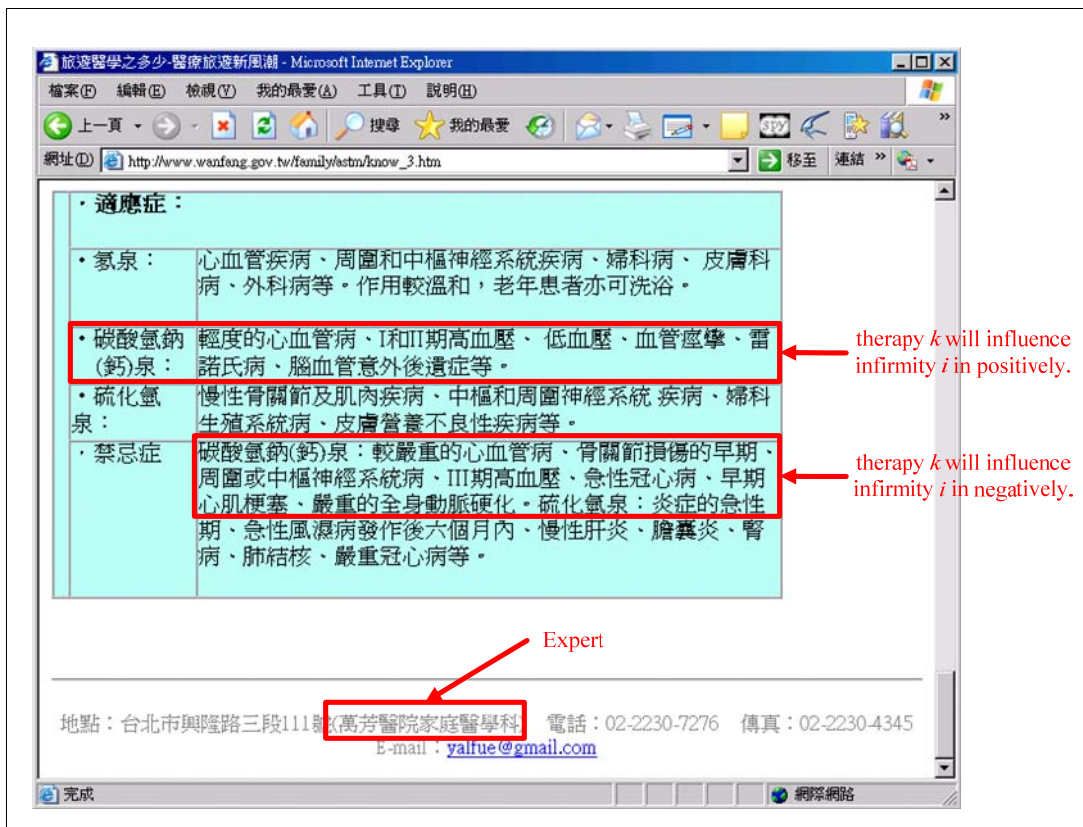


Figure. 5. A example of therapy suggestions from expert (Wan Fang Hospital) [67]

Where  $A_2 = \{aw_{in} \mid i \in I, n \in N\}$ , where  $aw_{in}$  is the influence weight of the infirmity  $i$  in the therapy  $n$  and

$aw_{in} = 1$  , if therapy  $n$  will influence infirmity  $i$  in positively.

$aw_{in} = 0$  , if therapy  $n$  won't influence infirmity  $i$ .

$aw_{in} = -1$  , if therapy  $n$  will influence infirmity  $i$  in negatively.

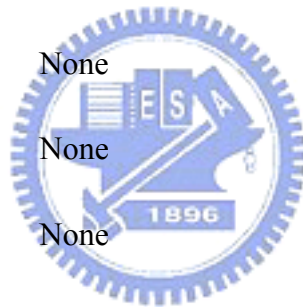
### 4.1.1.2 Medical Tourism Stemming Mechanism (MTSM)

To date, there are many stemming algorithms such as Brute Force Algorithms, Suffix Stripping Algorithms, Lemmatization Algorithms, and etc [63]. In this paper, we propose the Medical Tourism Stemming Mechanism (MTSM) based on CKIP segmentation system to process the special domain sentences referred to statistics and those algorithms. In addition to the affix-rules, a number of special conditions have to be designed to cover some specific medical tourism. The affix-rules which are distributed into three steps have the following general form:

affix  $\rightarrow$  substitution      <condition>

Step 1: This step includes several processes of the prefixes removing

Step 1 (a)	“可以” $\rightarrow \phi$	None
	“可” $\rightarrow \phi$	None
	“能” $\rightarrow \phi$	None
Step1 (b)	“有” $\rightarrow \phi$	None
	“患” $\rightarrow \phi$	None
Step 1 (c)	“治療” $\rightarrow \phi$	None
	“治” $\rightarrow \phi$	None
	“改善” $\rightarrow \phi$	None
Step 1 (d)	“較” $\rightarrow \phi$	None
Step 1 (e)	“嚴重” $\rightarrow \phi$	None
	“重度” $\rightarrow \phi$	None
	“輕度” $\rightarrow \phi$	None



Step 2: The step includes several processes of the infixes removing

Step 2 (a) “的” →  $\phi$  None

Step 2 (b) “和” →  $\phi$  None

“及” →  $\phi$  None

“或” →  $\phi$  None

“或者” →  $\phi$  None

Step 2 (c) “(-)” →  $\phi$  None

Note: This process is removing the term between the parts of speech “(PARENTHESISCATEGORY)”.

Step 2 (d) “-期” →  $\phi$  The part of speech of sentence “-期” is “(Na)”.

Note: This process is a **loop** until no the same term removed.

Step 3: This step includes several processes of the suffixes removing

Step 3 (a) “患者” →  $\phi$  None

“者” →  $\phi$  None

“人” →  $\phi$  None

Step 3 (b) “效果” →  $\phi$  None

Step 3 (c) “疾病” →  $\phi$  None

“病” →  $\phi$  Term length  $\geq 4$

“症狀” →  $\phi$  None

Step 3 (d) “過程” →  $\phi$  None

Step 3 (e) “傾向” →  $\phi$  None

Step 3 (f) “障礙”  $\rightarrow \phi$  None

Step 3 (g) “系統”  $\rightarrow \phi$  None

For example, there are seven segments “可(D)”, “治(VC)”, “輕度(A)”, “的(DE)”, “早期(Nd)”, “心血管(Na)”, “系統(Na)”, “疾病(Na)”, and “患者(Na)” of a sentence “可治輕度的早期心血管系統疾病患者”. Step 1 will remove “可(D)”, “治(VC)”, and “輕度(A)” orderly. And then after removing the segments “的(DE)” and “早期(Nd)” in step 2. Final, the segments “患者(Na)”, “疾病(Na)”, and “系統(Na)” are ordered to be removed in step 3, and the origin sentence will be replaced with the segment “心血管”. The matrix  $A_1$  and  $A_2$  will be decreased their dimension and became as follow.

$S_1 = \{sf_{jn} \mid j \in J, n \in N\}$ , where  $sf_{jn}$  is the frequency of the word  $j$  which is replaced from several infirmities  $i$  in the therapy  $n$  through stemming. And  $J$  is the number of the word  $j$ , where  $J \leq I$ .

$S_2 = \{sw_{jn} \mid j \in J, n \in N\}$ , where  $sw_{jn}$  is the influence weight of the word  $j$  which is replaced from several infirmities  $i$  in the therapy  $n$  through stemming.

#### 4.1.1.3 Medical Ontology (MO) and OWL-S Standard

The Medical Ontology (MO) focuses on medical classification, medical hierarchical architecture, and medical conception retrieval. We use the data of SOHO’s Medical Directory [56] to design MO which includes domain layer, category layer, concept layer, and extended subclass layer shown as Fig. 6. The domain layer represents the domain name (such as “疾病”) of MO and consists of different



categories (such as “內科”, “耳鼻喉科”, “外科”, and so on) defined by domain experts. Each category is made up of several concepts such as “心臟與血管疾病”, “呼吸系與胸部疾病”, “消化系與腹部疾病”, and so on.

We make use of protégé\_3\_3\_beta as the tool for editing MO. The meaning of each slot name resided in MO is defined by OWL-S standard. After building OWL-S document for interpreting the database of medical tourism service, we use the following query in OWLJessKB to tell if the input slot name is the subclass of one class in OWL-S document. For example, based on the OWL-S definition, the input slot name “心絞痛” is the subclass of “心臟疾病”, “心臟疾病” is the subclass of “心臟與心血管疾病”, and “心臟與心血管疾病” is the concept layer class in “內科”, and “內科” is the category layer class in the domain layer class “疾病”. Those infirmities are presented by hierarchical architecture in OWL-S document.

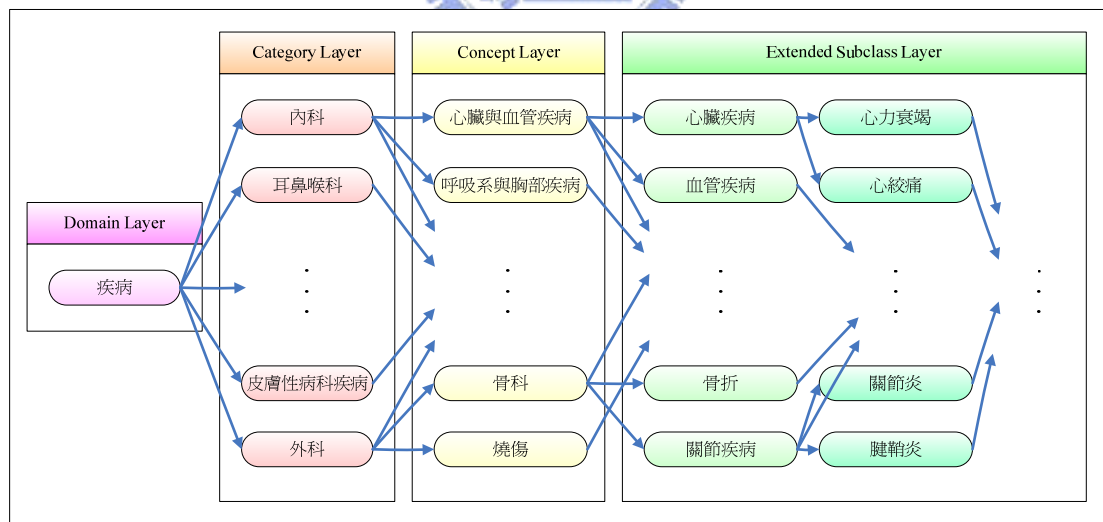


Figure. 6. The structure of Medical Ontology (MO)

There are multiple layers in MO, and we can get the best through comparing the different results from getting different levels of layer in MO. In this paper, we get the

concept layer in MO to retrieve medical conception to reduce the dimension of matrix. The matrix  $S_1$  and  $S_2$  will be decreased their dimension and became as follow.

$O_1 = \{of_{kn} | k \in K, n \in N\}$ , where  $of_{kn}$  is the frequency of the concept  $k$  which is replaced from several words  $j$  in the therapy  $n$  through MO conception retrieval. And  $K$  is the number of the concepts  $k$ , where  $K \leq J$ .

$O_2 = \{ow_{kn} | k \in K, n \in N\}$ , where  $ow_{kn}$  is the influence weight of the concept  $k$  which is replaced from several concepts  $k$  in the therapy  $n$  through MO conception retrieval.

#### **4.1.2 Adaptive Medical Tourism Service Inference Module (AMTSIM)**

Adaptive Medical Tourism Service Inference Module (AMTSIM) combines Term Frequency – Inversed Document Frequency (TF - IDF), Latent Semantic Analysis (LSA), and k-Nearest Neighbor (kNN) algorithm to inference adaptable MTS.



##### **4.1.2.1 Term Frequency – Inversed Document Frequency (TF - IDF)**

Salton and McGill [22] proposed that in order to decide the importance and representation of a term in a document, the TF in this document and the frequency of this term that appears in other documents can be calculated, which is called IDF. In this paper, we will calculate the TF – IDF values of matrix  $O_1$  into the matrix  $T$ .

$T = \{tf_{kn} | k \in K, n \in N\}$ , where  $tf_{kn}$  is the TFIDF value of the concept  $k$  which is replaced from matrix  $O_1$ .

$$tf_{kn} = TFIDF(k, n) = TF(k, n) \times IDF(k) = of_{kn} \times \log\left(\frac{|N|}{DF(k)}\right),$$

where  $TFIDF(k, n)$  is the weight of concept  $k$  in the therapy  $n$ ,  $DF(k)$  is the frequency of concept  $k$  in the therapy set, and  $k \in K, n \in N$ .

Final, we also consider the negative influence between infirmity and therapy to calculate the matrix  $L$ . Where  $L = T \otimes O_2 = \{lf_{kn} = tf_{kn} \times ow_{kn} \mid k \in K, n \in N\}$

#### 4.1.2.2 Latent Semantic Analysis (LSA)

We then perform Singular Value Decomposition (SVD) to  $L$ . The SVD of  $L$  is defined as  $L = UZV^T$ , where  $U$  is a  $K \times r$  matrix of left singular vectors,  $Z$  is a  $r \times r$  diagonal matrix of singular values, and  $V$  is a  $r \times N$  matrix of right singular vectors.  $r \leq \min(K, N)$  is rank of  $L$  [34].

The process of dimension reduction is applied to  $Z$  by deleting a few entries in it, and the result of dimension reduction is a matrix  $Z'$  which is a  $p \times p$  matrix. Let  $Z'$ , where  $p \leq r$ , be the diagonal matrix formed from the top  $k$  singular values, and let  $U'$  and  $V'$  be the matrices produced by selecting corresponding columns from  $U$  and  $V$ . A new matrix,  $L'$ , is reconstructed by multiplying three component matrixes, in the sense that it minimizes the approximation errors.

$$L' = U'Z'V'^T = \{lf'_{kn} \mid k \in K, n \in N\} \approx L$$

#### 4.1.2.3 k-Nearest Neighbor (kNN)

In this paper, a medical tourism inference model is trained by MTSM, MO, TF –

IDF, and LSA through different expert's suggestions into the matrix  $L'$  for inference. When MUs input their requirement, the SIM will translate the requirement to matrix  $Q$  on concept layer by MTSM and MO, and the AMTSIM will use the matrix  $L'$  to classify the requirement into the adaptive therapy by k-Nearest Neighbor (kNN). The algorithm for the kNN is as follows,

i) Let the user's requirement be a matrix  $Q$  on concept layer by MTSM, MO, and TF - IDF, where  $Q = \{qf_k | k \in K\}$ , where  $qf_k$  is the TFIDF value of the infirmity concept  $k$ , and  $of(k, q)$  is the term frequency of infirmity requirement in concept  $k$ .

$$qf_k = of_{(k,q)} \times \log\left(\frac{|N|}{DF(k)}\right), \text{ if user has infirmity } i \text{ of concept } k.$$

$qf_k = 0$ , otherwise.

ii) We also consider the negative influence between infirmity and therapy to calculate the similarity of the matrix  $Q$  and matrix  $L'$  as follows,

$$sim(Q, L'_n) = \frac{(\vec{Q} \cdot \vec{O}_2) \cdot \vec{L}'_n}{|\vec{Q} \times \vec{O}_2| \times |\vec{L}'_n|} = \frac{\sum_{k=1}^K [(qf_k \times ow_{kn}) \times lf'_{kn}]}{\sqrt{\sum_{k=1}^K [(qf_k \times ow_{kn})^2 \times (lf'_{kn})^2]}}$$

where  $k \in K, n \in N$  and  $0 \leq sim(Q, L'_n) \leq 1$

iii) The requirement matrix  $Q$  is assigned to the therapy class through kNN of  $Q$ .

## 4.2 System Architecture

The Situation-Aware Medical Tourism Service Search Subsystem (SAMTS<sup>3</sup>) is a five-tier system, shown as Fig. 7, Mobile Users (MUs) can utilize various terminal de-vices that include PC, notebook, Tablet PC, Personal Digital Assistant (PDA), and

mo-bile phone to access Medical Tourism Service Server (MTSS) through various web browsers. The UDDI Registries (UDDIRs) such as JUDDI offer UDDI standard APIs which are Inquiry API and Publication API for Medical Tourism Service Providers (MTSPs) and MTSS (as Service Requests). MTSPs are many kinds of various businesses which provide some Medical Tourism Services (MTS) to publish to UDDIRs. There are Intelligent Agents (IAs) and Model Base System (MBS) in the MTSS. There is the collecting of user's requirement information, geographical information, and web services cache in the database server. Relevant system functions design as follows.

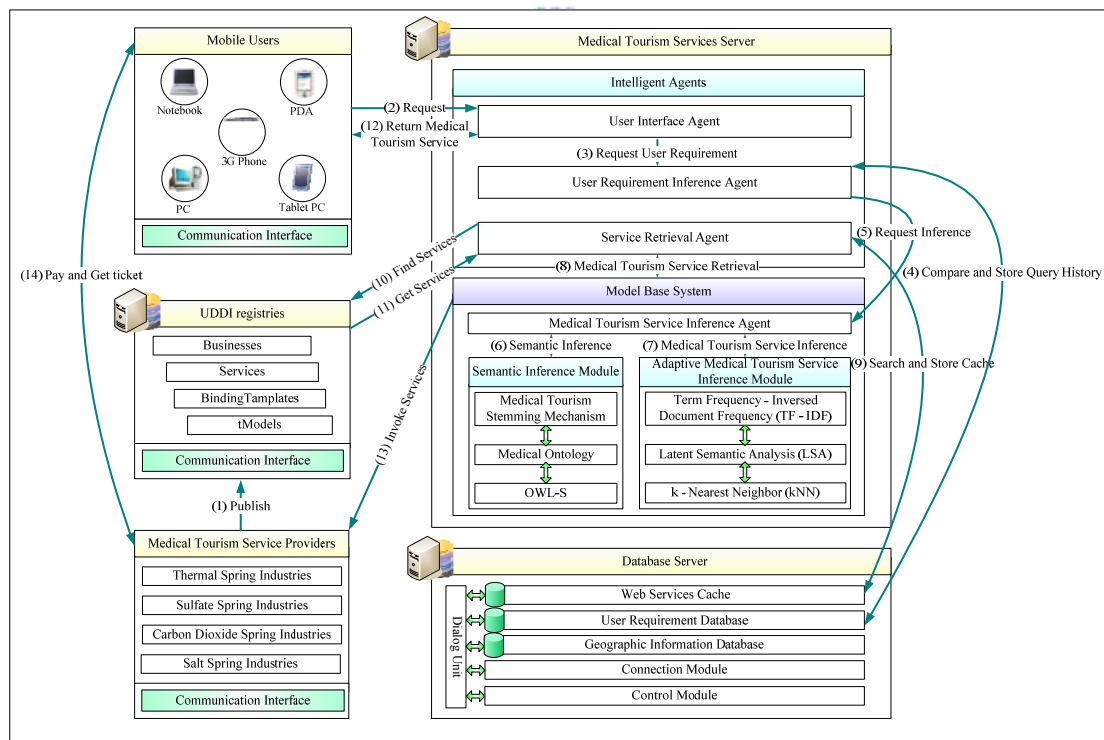


Figure. 7. The architecture of Situation-Aware Medical Tourism Service Search Subsystem (SAMTS<sup>3</sup>)

#### 4.2.1 Mobile Users (MUs)

Mobile users (MUs) provide the functions that include Adaptable Medical

Tourism Service (AMTS), Customized Service (CS), and Heterogeneous Networks (HN).

#### **4.2.1.1 Adaptable Medical Tourism Service (AMTS)**

MUs use mobile device to request their medical requirements to SAMTS<sup>3</sup>, in order to carry on the inference of MTS by MTSS using MBS and Semantic Inference Module (SIM). In this paper, Offering relevant adaptable MTS to users who can input difference symptoms in accordance with their situation (such as cardiopathy, inflammation, and etc.), and SAMTS<sup>3</sup> makes MTS reservation automatically according user request. Model of MBS depend on SIM and Adaptive Medical Tourism Service Inference Module (AMTSIM) to estimate. First, the MBS has been trained by several therapies experts proposed. When MUs input their requirements, the SIM will inference and translate the requirement sentences to be machine readable using stemming and ontology techniques. The AMTSIM offers Term Frequency – Inversed Document Frequency (TF - IDF), La-tent Semantic Analysis (LSA), and k-Nearest Neighbor (kNN) to provide adaptable MTS on different user's situation by similarity between user's requirement matrix and symptoms matrix.

#### **4.2.1.2 Customized Service (CS)**

While system has user's requirements and situation to provide customized services at time, including different requirements to provide different inference by semantic search engine. MUs will be easier to get relevant MTS information for step by step.

### **4.2.1.3 Heterogeneous Networks (HN)**

MUs use in the different network protocol , so the designing of system lets the terminal device or mobile equipment can be integrated services such environments as GSM, GPRS, 3G, wired network, IEEE802.11x wireless network, etc.

### **4.2.2 UDDI Registries (UDDIRs)**

The aim of semantic web is to locate services automatically based on the functionalities Web services provide. UDDI is helpful to discovery web services with semantic web. Therefore, we use the JUDDI to build UDDI environment which provides Business Entities, Service Entities, Binding Templates, and tModels to represent the detail of business and its services. Services in JUDDI can be searched by name, by location, by business, by bindings or by tModels. However, JUDDI doesn't support any inference based on the taxonomies referred to by the tModels. Integration of semantic web and JUDDI will solve this problem. And then, Service Retrieval Agent (SRA) can retrieve the detail and relationship of those services in JUDDI by UDDI4J APIs for the semantic inference easier.

### **4.2.3 Medical Tourism Service Providers (MTSPs)**

Medical Tourism Service Providers (MTSPs) build SOAP environment such as AXIS2 to provider some services for user invocation. After building services, MTSPs can publish the information of business, services, and binding templates to UDDIRs. For security, we can modify the AXIS2 API (such as upload.jsp) to build the hash code of service by MD5 algorithm. In this paper, MTSPs which can publish the MTS

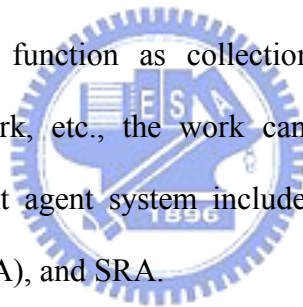
to UDDIRs through heterogeneous networks are Thermal Spring Industries, Sulfate Spring Industries, Carbon Dioxide Spring Industries, Salt Spring Industries, and etc.

#### **4.2.4 Medical Tourism Services Server (MTSS)**

The Medical Tourism Services Server (MTSS) offers the relevant services of MTS semantic search, those services compose of the Intelligent Agents (IAs) and Model Base System (MBS).

##### **4.2.4.1 Intelligent Agents (IAs)**

The IAs proceed such function as collection of the materials, searching, classifying, dealing with work, etc., the work can let users get the most MTS automatically. The in-telligent agent system includes User Interface Agent (UIA), User Requirement Agent (URA), and SRA.



##### **(1) User Interface Agent (UIA)**

To know that user's equipment type, when the users login in and give them the proper webpage.

##### **(2) User Requirement Inference Agent (URIA)**

To collect the user's requirement, such as query, operation, search history, and canned query, the information will be transmitted to the Medical Tourism Service Inference Agent (MTSIA) the DS in order to let the inference engine to analyze and



recom-mend in advance.

### **(3) Service Retrieval Agent (SRA)**

In traditional, the semantic web combined UDDI takes a long time to do the hierar-chical queries such as `find_business()`, `find_service()`, `find_binding()`, and `find_tModel()`. Therefore, we design the SRA to separate service information of huge quantity in UDDI to the Web Services Cache (WSC) in Database Server (DS), in order to save the time for accessing various UDDIRs by complex queries while MBS analyze the user's require-ments. SRA which is allowed an accelerated lookup process for finding the best match for users and their requirements is powerful to reduce the UDDI query processes to pro-vide a brilliant performance in the MTS inference. When MBS return the result, SRA will recommend MTS and invoke that service after user's submission.



#### **4.2.4.2 Model Base System (MBS)**

The Model Base System (MBS) includes intelligent deduction engine that uses Data Mining technology to produce the inference. First, the MTS are established automatically by the system, and the Medical Tourism Service Inference Agent (MTSIA) will recom-mend information to MUs for relevant services. The MBS provides MTSIA, Semantic Inference Module (SIM), Adaptive Medical Tourism Service Inference Module (AMTSIM), and other extension modules. The SIM is combined specific Medical Tour-ism Stemming Mechanism (MTSM), Medical Ontology (MO), and OWL-S standard to inference and translate the original sentences to be machine readable. And the AMTSIM uses the TF - IDF, LSA, and kNN to

calculate the similarity and inference the adaptive MTS.

First, MTSIA should be trained to find the relation between infirmities and therapies through SIM, AMTSIM, and training data from experts' suggestions shown as Fig. 3. SIM will translate each expert's suggestion to be a machine readable matrix and use MTSM, MO, and OWL-S standard to get conception matrix for inference. Second, AMTSIM will combine TF - IDF and LSA, and conception matrix to increase the accuracy. Final, when MUs request, user's requirement will be sent from MTSIA to SIM, and SIM translate the medical requirement to be a conception matrix for calculating the similarity between user's requirement matrix and symptoms matrix to find the adaptive therapy by kNN.

#### **4.2.5 Database Server (DS)**

The database server includes Web Service Caches (WSC), User Requirement Database (URD), Geographic Information Database (GID), connection module, and control module. The server also offers the web services properties and user requirements to store, and it is a powerful application tool to provide information to MTSS for MTS inference.

### **4.3 Evaluation and Case Study**

In this section, we report our experimental results and implement the architecture and approaches for Medical Tourism Service (MTS) as an example.

### 4.3.1 Evaluation

There are 46 expert's suggestions (such as therapy 1, therapy 2, ... , therapy 46) in the domain of medical tourism, and those data are collected from several web sites which are all provided by hospitals or doctors. We measure the performance of our approach in the way called *k*-fold cross-validation [28]. In our experiments, training and testing are performed 46 times (i.e.,  $k = 46$ ). In iteration *m*, therapy *m* is selected as the test corpus, and the other therapies are collectively used to train the values for each infirmity.

In this experiment, the feasibility of applying Medical Tourism Stemming Mechanism (MTSM), Medical Ontology (MO), or Latent Semantic Analysis (LSA) to MTS requirement classification is evaluated. Table 1 and 2 show classification index in kNN combined with MTSM, MO, or LSA.

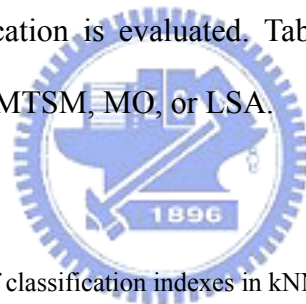


Table. 1. Accuracy rate of classification indexes in kNN with MTSM, MO, or LSA

	kNN			kNN+LSA		
	kNN	kNN+ MTSM	kNN+ MTSM+ MO	kNN+LSA	kNN+ MTSM+ LSA	kNN+ MTSM+M O+LSA
Micro-average	55.24%	60.01%	62.12%	66.59%	72.62%	69.54%
Macro-average	50.00%	58.70%	67.39%	58.70%	69.57%	73.91%

Table. 2. Classification indexes in kNN with MTSM, MO, or LSA

class	kNN			kNN+LSA		
	kNN	kNN+MTSM	kNN+MTSM+MO	kNN+LSA	kNN+MTSM+LSA	kNN+MTSM+MO+LSA
Air Bath	50.00%	50.00%	50.00%	75.00%	75.00%	75.00%
Thermal Spring	75.00%	75.00%	75.00%	75.00%	75.00%	75.00%
Sulfate Spring	50.00%	56.25%	75.00%	50.00%	62.50%	81.25%
Carbon Dioxide Spring	41.18%	58.82%	70.59%	52.94%	70.59%	76.47%
Salt Spring	60.00%	60.00%	40.00%	80.00%	80.00%	40.00%

Consider kNN first; it can be observed that its performances of classification are 50.00%, 75.00%, 50.00%, 41.18%, and 60.00% when the classes are “Air Bath”, “Thermal Spring”, “Sulfate Spring”, “Carbon Dioxide Spring”, and “Salt Spring”. The result shows that kNN algorithm combined MTSM, MO, and LSA to improve accuracy rates. Although, MO does not guarantee the obtained the most adaptable matrix always performs well for the MTS recommendations. For example, when kNN + MTSM + MO + LSA are combined, the performance of “Salt Spring” declines. In

view of macro-average, there is a higher accuracy rate about 73.91% from the best combination of approaches which are kNN + MTSM + MO + LSA. Therefore, we apply kNN with MTSM, MO, and LSA in SAMTS<sup>3</sup>.

### 4.3.2 A Case Study

The MTS reservation as one kind of web services is provided by various kinds of spring industries on the internet. SAMTS<sup>3</sup> helps patients or travelers find adaptable MTS for their remedy and traveling plans. Generally, users want to find MTS reservation services through UDDI or the current matchmaking for web services. In SAMTS<sup>3</sup>, the system will recommend adaptable MTS to MUs. The proposed method which is shown as Fig. 7 is applied to solve this problem according to the following procedures:

Step 1: Many medical tourism industries will provide their MTS reservation services on themselves SOAP site (such as AXIS2) and publish the information of those services which include company name, therapy name, location, price, and etc. to UDDIRs based on JUDDI.

Step 2: When MUs inquire the SRA for the adaptable MTS through UIA, they send their requirements as a part of the request.

Step 3~4: The UIA will send the MUs' requirement to URIA. For example, MUs input their infirmities “心臟病, 手腳冰冷, 胃腸功能障礙, 風濕症, 神經衰弱, 高血壓, 腎臟病, 過敏疾病, 慢性疾病, 酸痛, 關節炎” in PC and PDA to request SAMTS<sup>3</sup> shown as Fig. 8. and Fig 9. URIA supported the processes include lexical analysis will check and store user's information in URD for inference user's requirements.

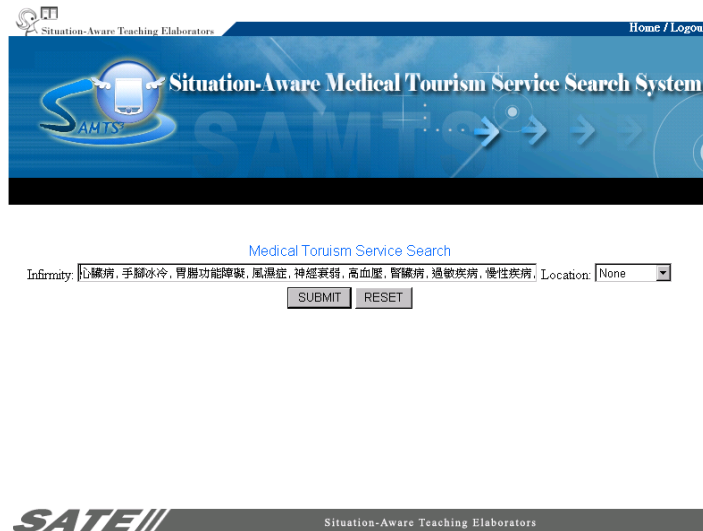


Figure. 8. Request SAMTS<sup>3</sup> in PC version



Figure. 9. Request SAMTS<sup>3</sup> in PDA version

Step 5: The URJA will get user's requirement from UIA and send it to MTSIA. When MTSIA receives the user's requirement inference result from URJA, it will control and coordinate various modules in MBS.

Step 6: The SIM will inference user's affinity information by MTSM and MO according to user's requirement from URJA. The text preprocess of SIM can segment the requirement to original word-by-document matrix which will be replaced with concept layer matrix  $Q$  by MTSM, MO, and Term Frequency – Inversed Document Frequency (TF - IDF). For example, the segment “心臟病” of this requirement will be presented the concept “心臟與血管疾病” and matrix  $Q$  is computed the TFIDF value of the concept “心臟與血管疾病”.

Step 7: To search the adaptable MTS, the AMTSIM will find the adaptable MTS class by LSA and kNN. The kNN will combine the negative influence weight value to calculate the similarity between matrix  $Q$  and trained matrix  $L'$  to get the most similar class such as “Carbon Dioxide Spring”. We can find the adaptable MTS class through

those processes above and MTSIA will sent this message to SRA for retrieval related MTS.

Step 8~11: The SRA holds up-to-date information on offers currently available for MTS which have been requested recently. To keep offer lists up-to-date, the SRA inquires the one or more UDDIRs periodically regularly in order to check, find, and get for new offers. When SRA receives the MTS class from MTSIA, SRA will query the Web Service Cache (WSC) and Geographic Information Database (GID) to get adaptive MTS.

Step 12~13: SAMTS<sup>3</sup> returns the result and recommends the adaptable MTS to MUs shown as Fig. 10. and Fig 11. If MUs agree this suggestion, SAMTS<sup>3</sup> will make those MTS reservation automatically.



Figure. 10. Response SAMTS<sup>3</sup> in PC version



Figure. 11. Response SAMTS<sup>3</sup> in PDA version

Step 14: MUs will pay the money to get MTS reservation which are booked MTS tickets and get those tickets and bills.

## 4.4 Discussion

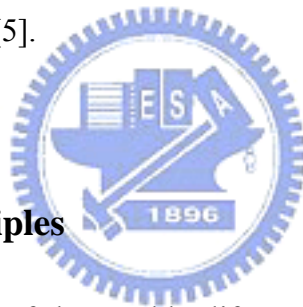
Recently there has a few medical tourism systems developed which mostly focus on location-aware service but no medical tourism service recommendation in Taiwan. In this research, we proposed a Situation-Aware Medical Tourism Service Search Subsystem, which provides user's requirements inference and relative services search by semantic inference engine and find the most adaptive Medical Tourism Service. We discover the accuracy of the MTS inference is higher by combining Medical Tourism Stemming Mechanism, Medical Ontology, Term Frequency – Inversed Document Frequency, Latent Semantic Analysis, and k-Nearest Neighbor. Mobile users can conveniently obtain customized MTS and decision to get and use those services according to their health requirement in advance by SAMTS<sup>3</sup>.

In the future, the MO can be modified to store more levels of medical tourism and other domain knowledge. For requirement classification, the similarity is computed by different level of MO to get adaptable medical tourism service from different industries. Otherwise, SAMTS<sup>3</sup> only focus now on Medical Hot Spring and can be integrated with more MTS inference for Psychotherapy, Mini Beauty Surgery, Premium Health exam, Dentistry, Ophthalmology Laser, and etc.



## Chapter 5 Healthy-life Map Guiding Subsystem (HMGS)

Healthy-Life tourism services are the trend of the future. In this paper, we propose an effective decision support system (DSS), the Healthy-life Map Guiding Subsystem (HMGS), which provides the introduction and commentaries of Healthy-Life scenic spots with relevant recommendation. HMGS is a three-tier system composed of the Clients, Multimedia Application Server (MAS), and Database Server (DS) to provide the introduction and commentaries of Healthy-Life scenic spots with relevant recommendation. HMGS is combined with an automatic text summarization technology to provide summary of commentaries. Finally, HMGS provides the adaptable tourism path in 3D web geographic information system for user reaching the Healthy-Life scenic spots [5].



### 5.1 System Design Principles

In this paper, the design of the Healthy-life Map Guiding Subsystem (HMGS) provides functions which are Blog Content Retrieval Agent (BCRA), Multiple Document Summarization (MDS), and etc.

BCRA searches the blog information from Google Blog Search and Yahoo Blog Search, and it finds the comment about the merchandise in blogs and store the Crawl and Parse into Blog Corpus. Finally, HMGS use Multiple Document Summarization technology which provides the introduction and commentaries of Healthy-Life scenic spots with relevant recommendation. Users can use the system interface to query relevant information. Overall system processes are shown as Fig. 12.

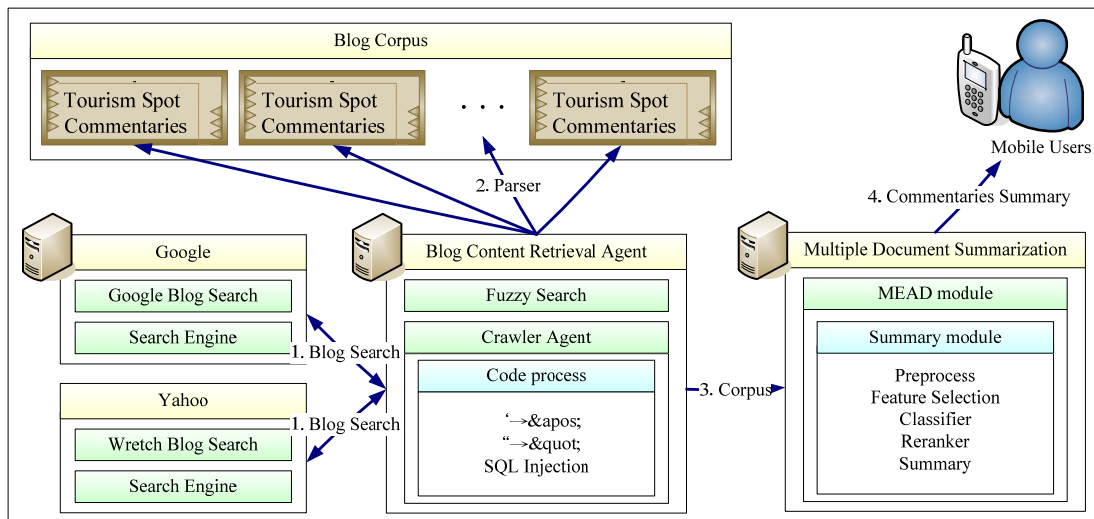
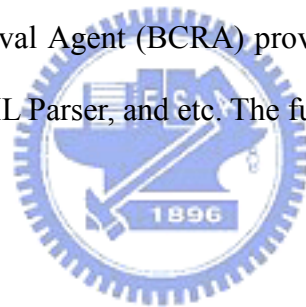


Figure. 12. The Process of Healthy-life Map Guiding Subsystem (HMGS)

### 5.1.1 Blog Content Retrieval Agent

The Blog Content Retrieval Agent (BCRA) provides functions which are Fuzzy Search, HTML Crawler, HTML Parser, and etc. The functions are shown as follows.



#### (1) Fuzzy Search

Fuzzy search provides fuzzy computing and judge. It establishes the keywords corpus and uses the terms in corpus to search the articles in blog by Google Blog Search or Yahoo Blog Search.

#### (2) HTML Crawler

HTML Crawler is used to create a copy of all the visited web pages for later processing by a fuzzy search. In this paper, HMGS uses the results of Google Blog Search in various Blogs and track related page link that HTML content will be saved.

### **(3) HTML Parser**

The HTML Parser analyses the HTML tag generated from HTML Crawler to get the key information. After that, it would remove the relevant special characters (such as single quotes and double quotes), and avoid attacks. Finally, we would establish Blog Corpus to get the summarization of multiple documents which is providing relevant recommendation.

## **5.1.2 Multiple Document Summarization**

Healthy-Life Map Guiding is combined Multiple Document Summarization technology to summarize automatically the various health-related spot blog comments in real-time and reduces the amount of information effectively. So that users can quickly browse the tourist of consumers' point of view and the past experience.

The Multiple Document Summarization uses MEAD package in our system. The relevant good comments in the Blog corpus is inputted into the MEAD modules which are (1) Preprocess, (2) Feature Selection, (3) Classifier, (4) Reranker, and (5) Summary to get text summarization automatically. The processes are shown as Fig. 13.

### **5.1.2.1 Preprocess**

In first step, preprocess would transfer the format of original HTML documents from blog. And then, set the documents ID and Sentence ID sequentially in order to carries on the weight of sentences in each document and the summary production.

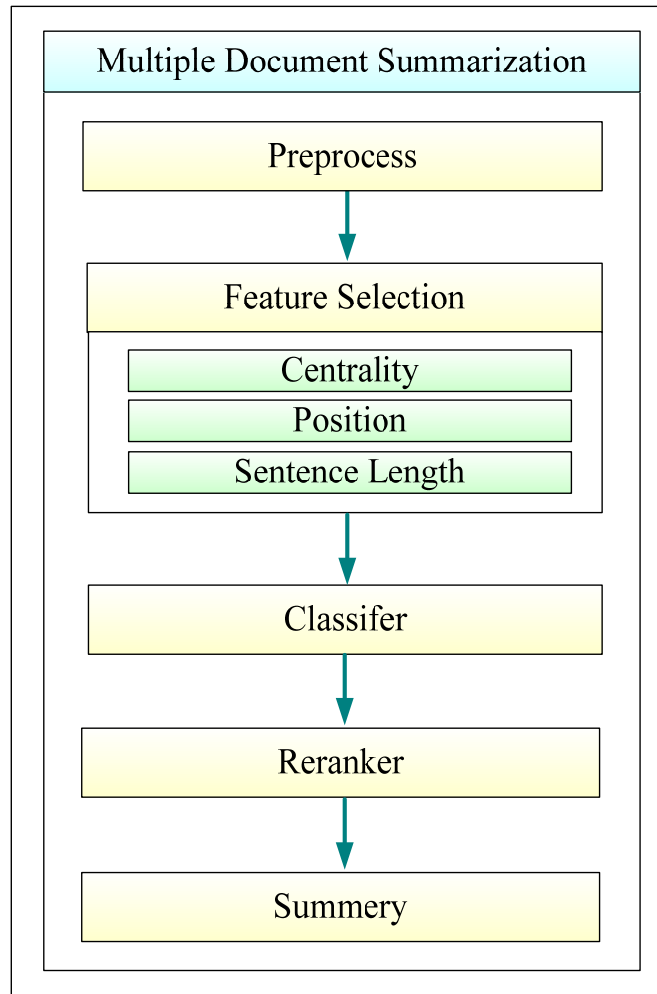


Figure. 13. MEAD's automatic text summarization process

### 5.1.2.2 Feature Selected

After that, HMGS uses several features which are (i) Centrality, (ii) Sentence Length, and (iii) Position to calculate the weight of each sentence.

#### (1) Centrality

I use the Vector Space Model (VSM) to carry out the similarity calculation. The maximum cosine value represents the centroid vector of the cluster. The following expression used to calculate the value of the sentence  $s$ .

$$Score_{Centrality}(s) = \frac{|keywords\ in\ s \cap\ keywords\ in\ other\ sentences|}{|keywords\ in\ s \cup\ keywords\ in\ other\ sentences|}$$

## (2) Sentence Length

If the length of the sentence is above a given threshold to be 1. Otherwise, the sentence length is 0. The following expression used to calculate the value of the sentence length.

$$Score_{Length}(s) = \begin{cases} 1, & Length(s) > n \\ 0, & Length(s) \leq n \end{cases}$$

## (3) Position

Position is to give the weight by the position of the sentence in the document. For the weight is divided into 10 levels: 0-9. 0: the sentence does not belong to a summary; 1-9: the sentence belongs to a summary. The importance: 1 is weakest, and 9 is strongest. The following expression used to calculate the value of the position of the sentence in the document.

$$Score_{Position}(s) = P(s \in S | Position_i) \times \frac{Average\ of\ Position_i}{9.0}$$

### 5.1.2.3 Classifier

In the third steps, we select some important features to set the different weight according to those features. We summarize those features and their weight to calculate the score of each sentence.

If Centrality weight is  $w_1$ , Position weight is  $w_2$ . The expression shows as follow.

$$Score_{Overall}(s) = [w_1 \times Score_{Centrality}(s) + w_2 \times Score_{Position}(s)] \times Score_{Length}(s)$$

#### 5.1.2.4 Reranker

In this step, we would judge the correlation in sentences which is decreased the redundancy. Next, we would set the threshold for filtering, and set the compression to extract.

#### 5.1.2.5 Summery

After that, we get the extract from Reranker and map the extract to summarize from Document ID and Sentence ID in this step of preprocess. Finally, Multiple Document Summarization technology provide summary of commentaries for users.



## 5.2 System Architecture and Implementation

Healthy-life Map Guiding Subsystem (HMGS) is three-tier architecture. Fig. 14 shows that user can access the data in the Multimedia Application Server (MAS) and the Database Server (DS) via personal computer, laptop, and tablet PC. MAS provides intelligent agents, multiple document summarization, real-time multimedia stream service and 3D web geographic information system. DS includes the blog corpus database, Healthy-Life scenic spots information, geographical information and the multimedia file database. The system functions are shown as follow.

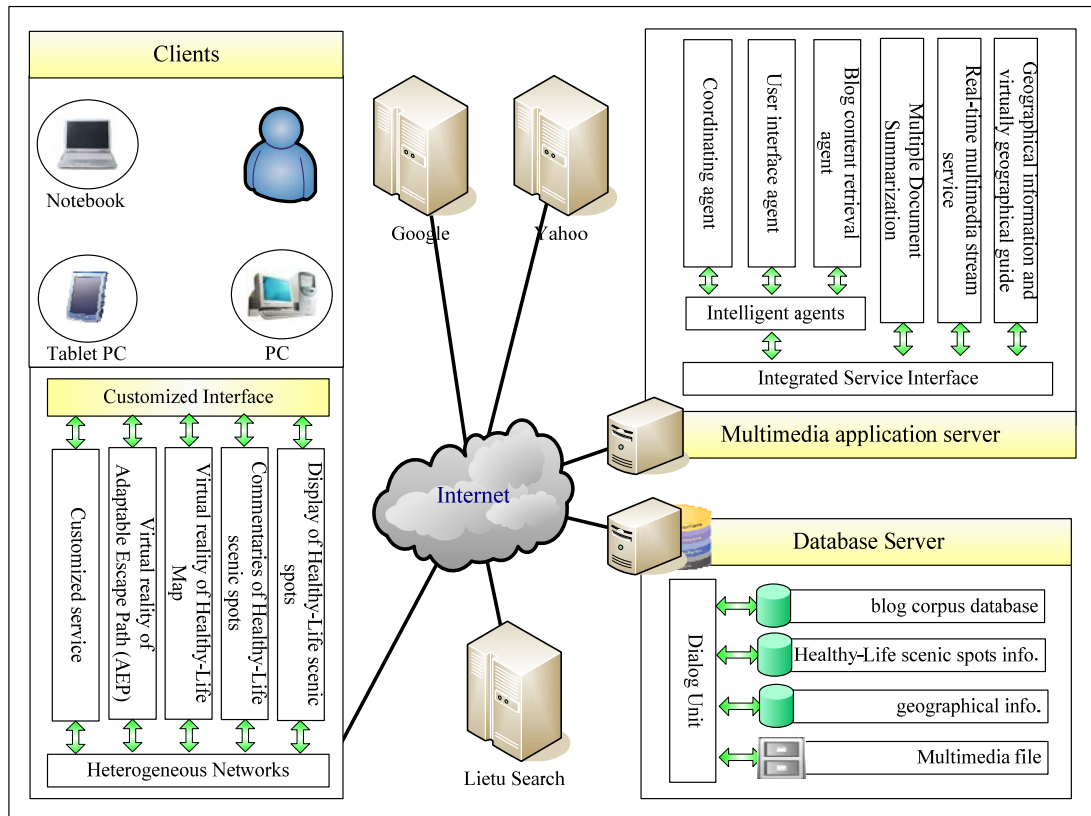


Figure. 14. The architecture of Healthy-life Map Guiding Subsystem (HMGS)

### 5.2.1 Clients

The user can acquire (i) the tourist introduction of every Healthy-Life scenic spots, (ii) the relevant comment of every Healthy-Life scenic spots, and (iii) the virtually geographical guide. This paper retrieve the relevant comments from blogs via Blog Content Retrieve Agent (BCRA), and provide the scenic spots comment summaries via Multiple Document Summarization, plus the route guiding service, to help user make their tourist decision.

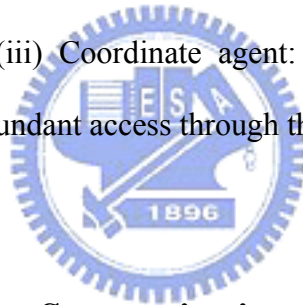
### 5.2.2 Multimedia Application Server (MAS)

Multimedia application server mainly provides intelligent agent, multiple

documents summarization, real-time multimedia stream service, geographic information and virtual route guide service, and etc.

### **5.2.2.1 Intelligent Agent (IA)**

Intelligent agent does the data collection, searching, classifying, and processing. It can quickly help the user retrieve all the latest information he/she needs. This paper separates the agent function into three kinds of agent, (i) Blog Content Retrieve Agent: it provides the fuzzy searching mechanism, HTML Crawler, and HTML Parser to search and abstract the blog document; (ii) User interface agent: it distinguishes the equipment from the user side. When the user connects to the internet, it will provide the appropriate web pages; (iii) Coordinate agent: it coordinates the information transmission, avoiding the redundant access through the server and the user side.



### **5.2.2.2 Multiple Document Summarization (MDS)**

When the MDS retrieves the comment article of the Healthy-Life scenic spot from blog content, HMGS summarize the document by using MDS. It helps user to understand the scenic spot more so that the user can decide if he/she is going to the spot. The English MDS part is done by MEAD procedure, and it use Centrality, Sentence Length, Position these three features to calculate the importance of the sentence. Finally, it yields the summarization by the adjustment of the sentence from Classifier and Reranker, as showed in Fig. 15. The Chinese MDS is done by the agent mechanism, which was implemented by the “Lietu Search” [41], as showed in Fig. 16. The user will see the final result on the web page as showed in Fig. 17.



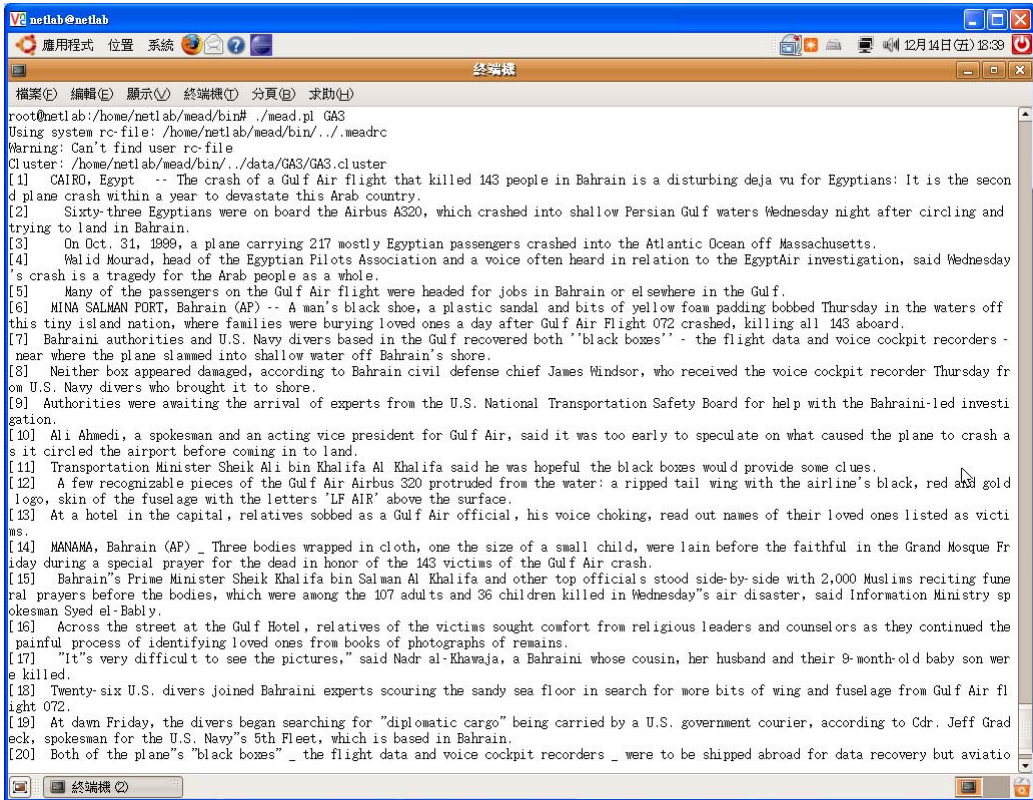


Figure 15. The implementation of MDS by MEAD

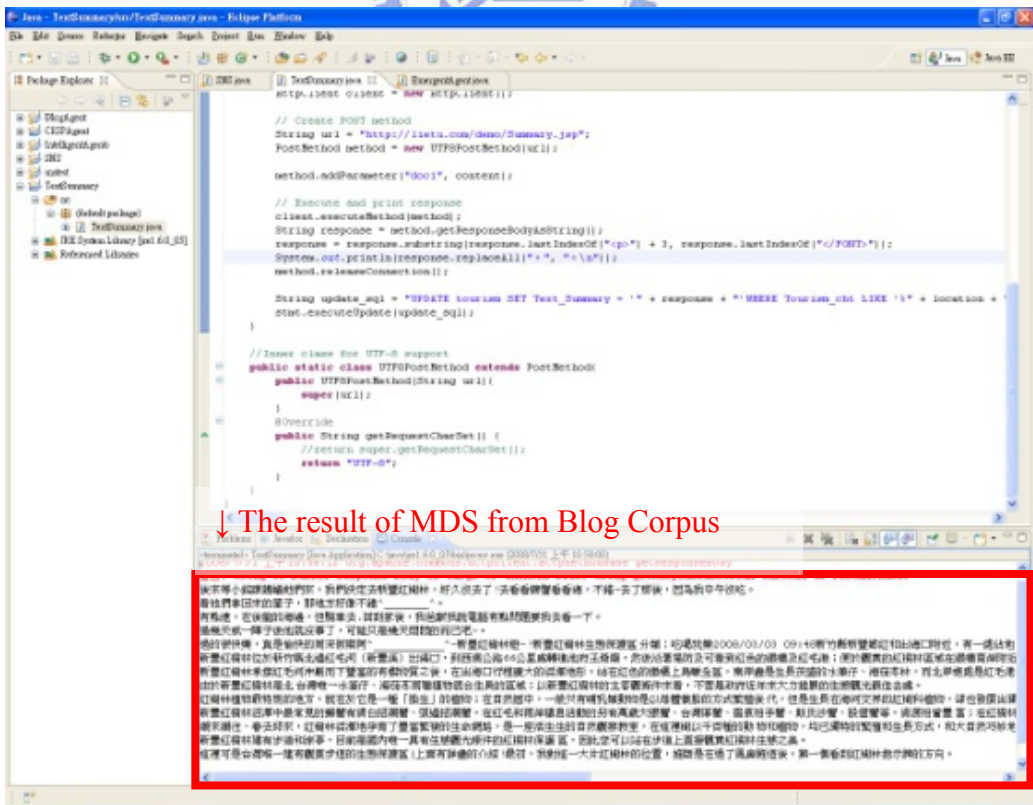


Figure 16. The implementation of MDS by Lietu Search

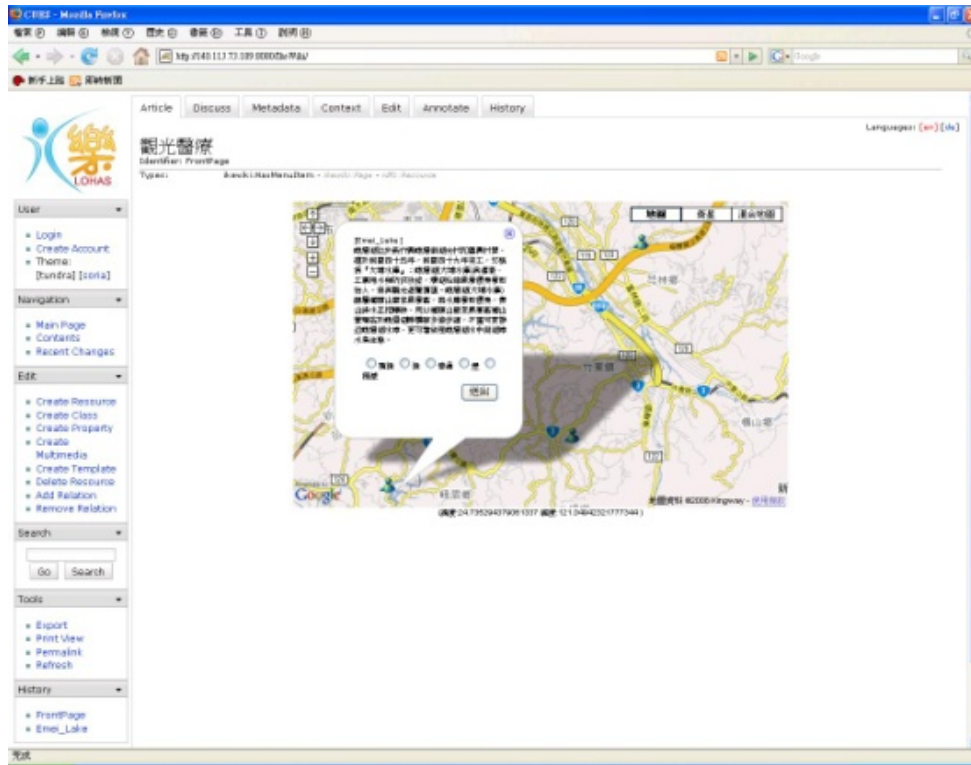


Figure. 17. The introduction and commentaries of Healthy-Life scenic spots



### 5.2.2.3 Real-time Multimedia Stream Service (RMSS)

This paper integrates the real-time multimedia information of scenic spot in with the HMGS system, so the user can find the real-time image of the Healthy-Life scenic spot [59].

### 5.2.2.4 Geographical Information and Virtually Geographical Guide

This paper presents the geographical information virtually through the Google map and Google earth API, and it also integrates the shortest path algorithm from the multimedia application server. According to the starting point and the destination set by the user, it will provide the map guide service virtually and show the route plan.

### **5.2.3 Database Server (DS)**

The back-end database server owns the blog article database, the Healthy-Life scenic spot database, geographical information database, media file database. It integrates the information and store in the media database, and it provides the scenic spot information and reliable information about the Healthy-Life activities. It becomes an important tool of present Healthy-Life guiding service.

## **5.3 Discussion**

This paper focuses on the integrated recommendation of tourist and Healthy-Life information, and develops Healthy-Life Map Guiding Subsystem (HMGS), which provides relevant recommendation of the Healthy-Life scenic spot and furthermore provides an integrated service platform. Also, HMGS combines the Healthy-Life scenic spot introduction and relevant comment, summarizes the information, and collaborates with the real-time image which can guide the user to the tourist spot fast and clearly. In addition, it designs the 3D virtual reality and route guiding scheme so that it can guide the user how to get to the tourist spot, and the user can watch the tourist spot from the 3D virtual reality. HMGS intends to let the user conveniently enjoy a Healthy-Life while on a trip.

However, HMGS only focus now on multiple document summarization technology for users' experiences. In the future, HMGS can consider with client's interest and native users' comments with Location-Based Service (LBS) to provide more precise recommendation.

## Chapter 6 Intelligent Curative Food Decision Support

### Subsystem (ICFDSS)

While economy and health concept are raises, most food full on markets. How uses food to preserve people's health is a popular topic. In this paper, we proposed and developed the “Intelligent Curative Food Decision Support Subsystem (ICFDSS)” to record efficiently user’s diet. Using micro sensors integrate RFID to sense user’s life vital signal, such as electrocardiogram (ECG/EKG), heart rate (HR), respiratory rate (RR), blood pressure (BP), blood sugar (BS), and treatment and light. On the other hand, ICFDSS achieves balance diet that can provide diet exhorting and suggestion by Medical Ontology, Latent Semantic Analysis, and k-Nearest Neighbor etc [6].

#### 6.1 System Design Principle



First, the Curative Food Service (CFS) is established automatically by the system, and the Curative Food Service Inference Agent (CFSIA) will recommend information to MUs for relevant services. The IE provides CFSIA, Semantic Process Module (SPM), Adaptive Curative Food Service Inference Module (ACFSPM), and other extension modules. The SPM is combined specific Curative Food Stemming Mechanism (CFSM), Medical Ontology (MO), and OWL-S standard to inference and translate the original sentences to be machine readable. And the ACFSPM uses the TF-IDF, LSA, and kNN to calculate the similarity and inference the adaptive CFS.

##### 6.1.1 Curative Food Service Inference Agent (CFSIA)

First, CFSIA should be trained to find the relationship between infirmities and

therapies through SPM, ACFSPM, and training data from several experts' suggestions shown as Fig. 18.

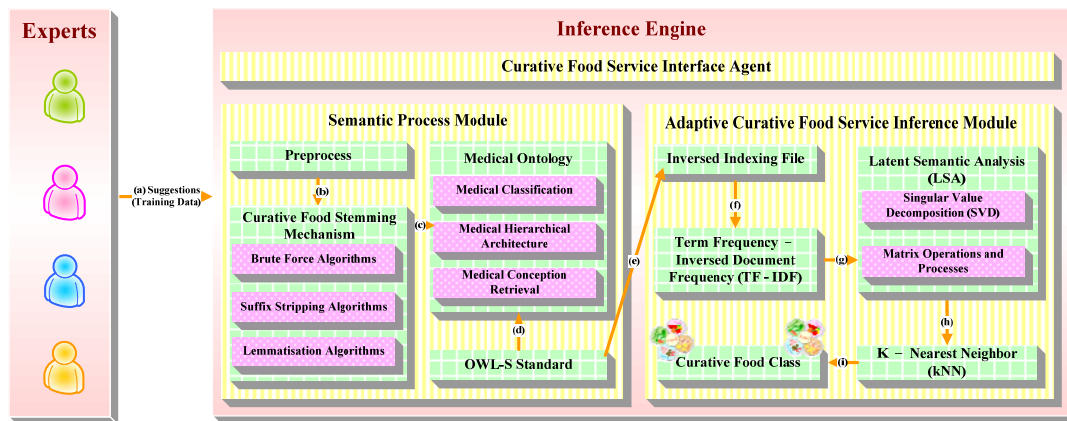


Figure. 18. Curative food knowledge training process of IE

SPM will translate each expert's suggestion to be a machine readable matrix and use CFSM, MO, and OWL-S standard to get conception matrix for inference. Second, ACFSPM will combine TF - IDF and LSA, and conception matrix to increase the accuracy. Final, when MUs request, user's requirement will be sent from CFSIA to SPM, and SPM translate the medical requirement to be a conception matrix for calculating the similarity between user's requirement matrix and symptoms matrix to find the adaptive therapy by kNN.

### 6.1.2 Semantic Process Module (SPM)

The Semantic Process Module (SPM) exploits CFSM and MO to explain and to represent the data of expert's suggestions and user's requirement.

### (i) Preprocess

Preprocess translate the different expert's suggestions and user's requirements to be the vector space model. During training time, the collection of therapy suggestions as a set of documents will be represented by a word-by-document matrix  $A_1$  and  $A_2$ , where each entry represents the occurrences of a infirmity as a word in a document, i.e.  $A_1 = \{af_{in} \mid i \in I, n \in N\}$ , where  $af_{in}$  is the frequency of the infirmity  $i$  in the therapy  $n$ . Let  $I$  be the number of the occurrence of all the infirmities in those therapies and  $N$  be the number of the occurrence of all the collected therapies.

Where  $A_2 = \{aw_{in} \mid i \in I, n \in N\}$ , where  $aw_{in}$  is the influence weight of the infirmity  $i$  in the therapy  $n$  and

$aw_{in} = 1$ , if therapy  $n$  will influence infirmity  $i$  in positively.

$aw_{in} = 0$ , if therapy  $n$  won't influence infirmity  $i$ .

$aw_{in} = -1$ , if therapy  $n$  will influence infirmity  $i$  in negatively.



### (ii) Curative Food Stemming Mechanism (CFSM)

To date, there are many stemming algorithms such as Brute Force Algorithms, Suffix Stripping Algorithms, Lemmatization Algorithms, and etc [63]. In this paper, we propose the Curative Food Stemming Mechanism (CFSM) based on CKIP segmentation system to process the special domain sentences referred to statistics and those algorithms. In addition to the affix-rules, a number of special conditions have to be designed to cover some specific curative food. The matrix  $A_1$  and  $A_2$  will be decreased their dimension and became as follow.

$S_1 = \{sf_{jn} \mid j \in J, n \in N\}$ , where  $sf_{jn}$  is the frequency of the word  $j$  which is replaced from several infirmities  $i$  in the therapy  $n$  through stemming. And  $J$  is the number of the word  $j$ , where  $J \leq I$ .

$S_2 = \{sw_{jn} \mid j \in J, n \in N\}$ , where  $sw_{jn}$  is the influence weight of the word  $j$  which is replaced from several infirmities  $i$  in the therapy  $n$  through stemming.

### (iii) Medical Ontology (MO) and OWL-S Standard

The Medical Ontology (MO) focuses on medical classification, medical hierarchical architecture, and medical conception retrieval. We use the data of SOHO's Medical Directory [56] to design MO which includes domain layer, category layer, concept layer, and extended subclass layer. There are multiple layers in MO, and I can get the best through comparing the different results from getting different levels of layer in MO. In this paper, we get the concept layer in MO to retrieve medical conception to reduce the dimension of matrix. The matrix  $S_1$  and  $S_2$  will be decreased their dimension and became as follow.

$O_1 = \{of_{kn} \mid k \in K, n \in N\}$ , where  $of_{kn}$  is the frequency of the concept  $k$  which is replaced from several words  $j$  in the therapy  $n$  through MO conception retrieval. And  $K$  is the number of the concepts  $k$ , where  $K \leq J$ .

$O_2 = \{ow_{kn} \mid k \in K, n \in N\}$ , where  $ow_{kn}$  is the influence weight of the concept  $k$  which is replaced from several concepts  $k$  in the therapy  $n$  through MO conception retrieval.

### 6.1.3 Adaptive Curative Food Service Inference Module (ACFSPM)

The Adaptive Curative Food Service Inference Module (ACFSPM) combines Term Frequency – Inversed Document Frequency (TF - IDF), Latent Semantic Analysis (LSA), and kNN algorithm to inference adaptable CFS.

#### (i) Term Frequency–Inversed Document Frequency

Salton and McGill [22] proposed that in order to decide the importance and representation of a term in a document, the TF in this document and the frequency of this term that appears in other documents can be calculated, which is called IDF. In this paper, we will calculate the TF – IDF values of matrix  $O_1$  into the matrix  $T$ .

$T = \{tf_{kn} \mid k \in K, n \in N\}$ , where  $tf_{kn}$  is the TFIDF value of the concept  $k$  which is replaced from matrix  $O_1$ .



$$tf_{kn} = TFIDF(k, n) = TF(k, n) \times IDF(k) = of_{kn} \times \log\left(\frac{|N|}{DF(k)}\right)$$

where  $TFIDF(k, n)$  is the weight of concept  $k$  in the therapy  $n$ ,  $DF(k)$  is the frequency of concept  $k$  in the therapy set, and  $k \in K, n \in N$ .

Final, we also consider the negative influence between infirmity and therapy to calculate the matrix  $L$ .

$$\text{Where } L = T \otimes O_2 = \{lf_{kn} = tf_{kn} \times ow_{kn} \mid k \in K, n \in N\}$$



## (ii) Latent Semantic Analysis (LSA)

I then perform Singular Value Decomposition (SVD) to  $L$ . The SVD of  $L$  is defined as  $L = UZV^T$ , where  $U$  is a  $K \times r$  matrix of left singular vectors,  $Z$  is a  $r \times r$  diagonal matrix of singular values, and  $V$  is a  $r \times N$  matrix of right singular vectors.  $r \leq \min(K, N)$  is rank of  $L$  [34].

The process of dimension reduction is applied to  $Z$  by deleting a few entries in it, and the result of dimension reduction is a matrix  $Z'$  which is a  $p \times p$  matrix. Let  $Z'$ , where  $p \leq r$ , be the diagonal matrix formed from the top  $k$  singular values, and let  $U'$  and  $V'$  be the matrices produced by selecting corresponding columns from  $U$  and  $V$ . A new matrix,  $L'$ , is reconstructed by multiplying three component matrixes, in the sense that it minimizes the approximation errors.

$$L' = U'Z'V'^T = \{lf'_{kn} \mid k \in K, n \in N\} \approx L$$



## (iii) k-Nearest Neighbor (kNN)

In this paper, a curative food inference model is trained by CFSM, MO, TF – IDF, and LSA through different expert's suggestions into the matrix  $L'$  for inference. When MUs input their requirement, the SPM will translate the requirement to matrix  $Q$  on concept layer by CFSM and MO, and the ACFSPM will use the matrix  $L'$  to classify the requirement into the adaptive therapy by kNN. The algorithm for the kNN is as follows,

i) Let the user's requirement be a matrix  $Q$  on concept layer by CFSM, MO, and TF - IDF, where  $Q = \{qf_k \mid k \in K\}$ , where  $qf_k$  is the TFIDF value of the infirmity concept  $k$ , and  $of(k, q)$  is the term frequency of infirmity requirement in concept  $k$ .

$$qf_k = of_{(k,q)} \times \log\left(\frac{|N|}{DF(k)}\right), \text{ if user has infirmity } i \text{ of concept } k.$$

$qf_k = 0$ , otherwise.

ii) I also consider the negative influence between infirmity and therapy to calculate the similarity of the matrix  $Q$  and matrix  $L'$  as follows,

$$sim(Q, L'_n) = \frac{(\vec{Q} \cdot \vec{O}_2) \cdot \vec{L}'_n}{|\vec{Q} \times \vec{O}_2| \times |\vec{L}'_n|} = \frac{\sum_{k=1}^K [(qf_k \times ow_{kn}) \times lf'_{kn}]}{\sqrt{\sum_{k=1}^K [(qf_k \times ow_{kn})^2 \times (lf'_{kn})^2]}}$$

where  $k \in K, n \in N$  and  $0 \leq sim(Q, L'_n) \leq 1$

iii) The requirement matrix  $Q$  is assigned to the therapy class through kNN of  $Q$ .

## 6.2 System Architecture



The Intelligent Curative Food Decision Support Subsystem (ICFDSS) is a six components system, shown as Fig. 19.

### 6.2.1 Mobile Medical Monitor (M<sup>3</sup>)

Mobile Medical Monitor builds in user's home, that using micro sensors senses user's life vital signal, such as electrocardiogram (ECG/EKG), heart rate (HR), respiratory rate (RR), blood pressure (BP), blood sugar (BS), temperature, and light parameters. On the other hand, the system utilizes PDA with RFID Reader which can sense user's diet daily. The record in diet diary integrates with weight control, diet exhorting and suggestion, and to remind user to achieve balance diet.

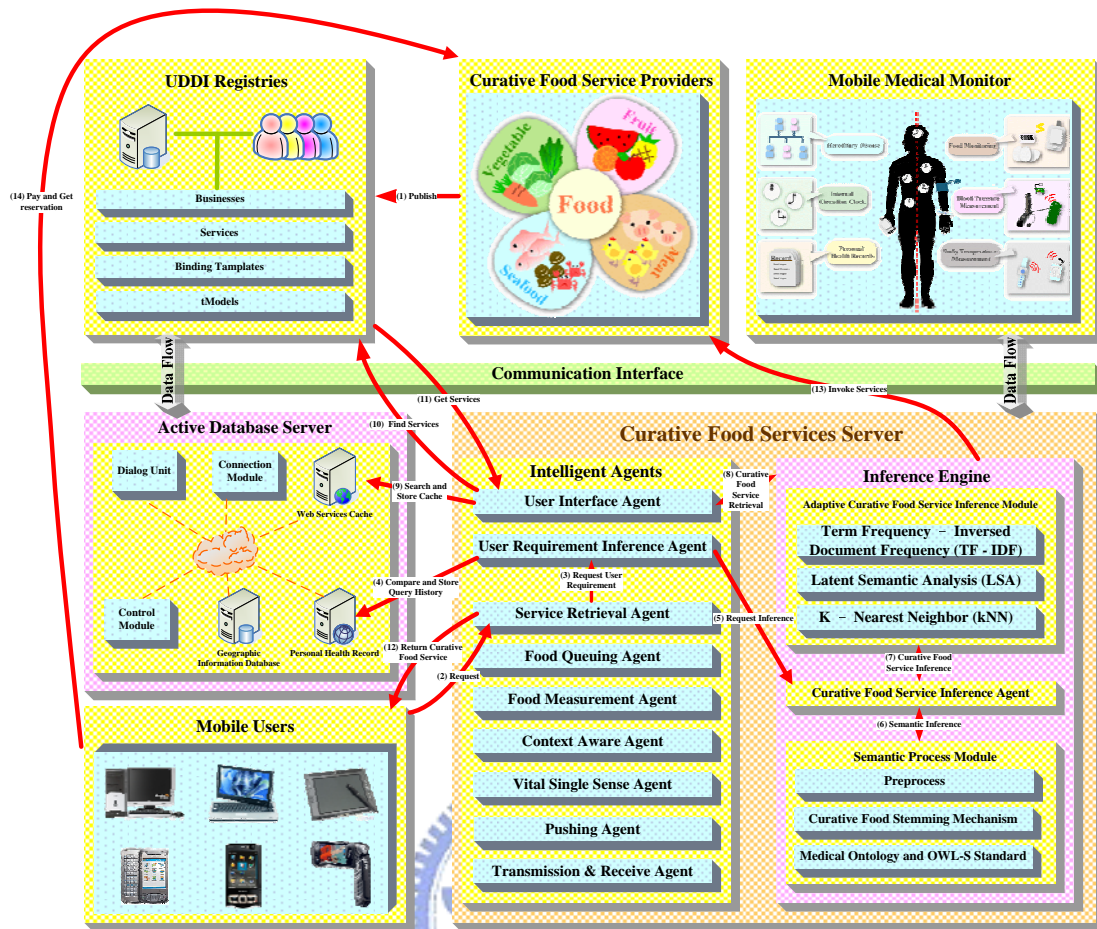


Figure. 19. The architecture of Intelligent Curative Food Decision Support Subsystem

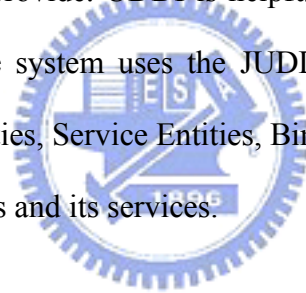
User can wear RFID Tag wristband watch to sense body temperature. When users break away the RFID Tag wristband watch, the system can take advantage of light sensor and buzzer to remind user [12, 74]. On the other hand, parameters of ECG/EKG, HR, RR, BP, BS, temperature, and light can be stored in database by micro sensors. The programs can store in database and transform parameters to line charts, and then user can view vital signal parameters by mobile devices (PDA, mobile phone, tablet PC, and etc). The trend of line chart is convenient to view by user, user's family, and doctor.

### **6.2.2 Mobile Users (MUs)**

MUs provide the functions that include Adaptable Curative Food Service (ACFS), Customized Service (CS), and Heterogeneous Networks (HN). MUs use mobile device to request their medical requirements to ICFDSS, in order to carry on the inference of CFS by CFSS using Inference Engine (IE) and Semantic Process Module (SPM).

### **6.2.3 UDDI Registries (UDDIRs)**

The aim of semantic web is to locate services automatically based on the functionalities Web services provide. UDDI is helpful to discover web services with semantic web. Therefore, the system uses the JUDDI to build UDDI environment which provides Business Entities, Service Entities, Binding Templates, and tModels to represent the detail of business and its services.



### **6.2.4 Curative Food Service Providers (CFSPs)**

Curative Food Service Providers (CFSPs) build SOAP environment such as AXIS2 to provide some services for user invocation. After building services, CFSPs can publish the information of business, services, and binding templates to UDDIRs.

### **6.2.5 Curative Food Services Server (CFSS)**

The Curative Food Services Server (CFSS) offers the relevant semantic searching services of CFS, those services compose of the IAs and IE.

### **6.2.5.1 Intelligent Agents (IAs)**

The IAs proceed such function as the materials of collection, searching, classifying, dealing with work, etc., the work can let users get the most CFS automatically. The intelligent agent system includes User Interface Agent (UIA), User Requirement Inference Agent (URIA), and Service Retrieval Agent (SRA).

#### **(1) User Interface Agent (UIA)**

To know that user's equipment type, the users login in and give them the proper webpage.

#### **(2) User Requirement Inference Agent (URIA)**

To collect the user's requirement, such as query, operation, searching history, and canned query, the information will be transmitted to the Curative Food Service Inference Agent (CFSIA) the ADS in order to let the inference engine to analyze and recommend in advance.

#### **(3) Service Retrieval Agent (SRA)**

In traditional, the semantic web with UDDI takes a long time to do the hierarchical queries such as `find_business()`, `find_service()`, `find_binding()`, and `find_tModel()`. Therefore, the SRA is designed to separate service information of huge quantity in UDDI to the Web Services Cache (WSC) in Active Database Server, in order to save the time for accessing various UDDIRs by complex queries while IE

analyze the user's requirements. SRA which is allowed an accelerated lookup process for finding the best match for users and their requirements is powerful to reduce the UDDI query processes to provide a brilliant performance in the CFS inference. When IE return the result, SRA will recommend CFS and invoke that service after user's submission.

#### **(4) Food Queuing Agent (FQA)**

This function can combine the internal circadian clock and VS<sup>2</sup>A recommending to user's food, and preventing user eating food on outside time.

#### **(5) Food Measurement Agent (FMA)**

FMA utilizes PDA with RFID Reader which can sense and record user's diet and calorie daily.



#### **(6) Context Aware Agent (CA<sup>2</sup>)**

The CA<sup>2</sup> integrates FQA and VS<sup>2</sup>A function to sense micro sensors user's temperature on waking up.

#### **(7) Vital Single Sense Agent (VS<sup>2</sup>A)**

VS<sup>2</sup>A makes use of micro sensor and RFID to sense user's parameters that can stores and records by exploiting TRA.

### **(8) Pushing Agent (PA)**

Pushing agent can classify into two functions, one of normal condition can integrates of CA<sup>2</sup> and pushing messages for user's and doctor's mobile devices. Another alerting condition makes use of VS<sup>2</sup>A sensor sensing over user's normal range.

### **(9) Transmission & Receive Agent (TRA)**

This function can access user's parameters to store on database, such as electrocardiogram (ECG/EKG), heart rate (HR), respiratory rate (RR), blood pressure (BP), blood sugar (BS), temperature and light.

#### **6.2.5.2 Inference Engine (IE)**

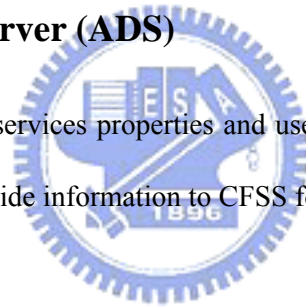


The Inference Engine (IE) includes intelligent deduction engine that uses Data Mining technology to produce the inference. First, the CFS is established automatically by the system, and the Curative Food Service Inference Agent (CFSIA) will recommend information to MUs for relevant services. The IE provides CFSIA, Semantic Process Module (SPM), A Adaptive Curative Food Service Inference Module (ACFSPM), and other extension modules. The SPM is combined specific Curative Food Stemming Mechanism (CFSM), Medical Ontology (MO), and OWL-S standard to inference and translate the original sentences to be machine readable. And the ACFSPM uses the TF - IDF, LSA, and kNN to calculate the similarity and inference the adaptive CFS.

First, CFSIA should be trained to find the relation between infirmities and therapies through SIM, ACFSPM, and training data from experts' suggestions shown as Fig. 18. SIM will translate each expert's suggestion to be a machine readable matrix and use CFSSM, MO, and OWL-S standard to get conception matrix for inference. Second, ACFSPM will combine TF - IDF and LSA, and conception matrix to increase the accuracy. Final, when MUs request, user's requirement will be sent from CFSIA to SPM, and SPM translate the medical requirement to be a conception matrix for calculating the similarity between user's requirement matrix and symptoms matrix to find the adaptive therapy by kNN.

### **6.2.6 Active Database Server (ADS)**

The server offers the web services properties and user requirements to store, and it is a powerful application tool to provide information to CFSS for CFS inference.



## **6.3 System Evaluation and Case Study**

In this section, we report our experimental results and implement the architecture and approaches for Curative Food Service (CFS) as an example.

### **6.3.1 Evaluation**

There are 76 expert's suggestions (such as therapy 1, therapy 2, ... , therapy 76) in the domain of curative food, and those data are collected from several web sites, books, and papers which are all provided by dietitians or doctors. We measure the performance of our approach in the way called k-fold cross-validation [28]. In our experiments, training and



testing are performed 76 times (i.e.,  $k = 76$ ). In iteration  $m$ , therapy  $m$  is selected as the test corpus, and the other therapies are collectively used to train the values for each infirmity.

In this experiment, the feasibility of applying Curative Food Stemming Mechanism (CFSM), Medical Ontology (MO), or Latent Semantic Analysis (LSA) to CFS requirement classification is evaluated. Table 3 show classification index in kNN combined with CFSM, MO, or LSA. Firstly, we consider kNN model that can be observed performances of classification are 21.05%, 26.32%, 68.42%, and 42.11%, then the average is 39.47% when the classes are “Fruit”, “Meat”, “Seafood”, and “Vegetable”. The result shows that kNN algorithm combined CFSM, MO, and LSA to improve accuracy rates. In view of micro-average, there is a higher accuracy rate about 75.00% from the best combination approaches which are kNN + CFSM + MO + LSA. Therefore, we apply kNN with CFSM, MO, and LSA in ICFDSS.



### 6.3.2 Case Study

In this section, we implement ICFDSS and show the results with a case study.

#### 6.3.2.1 Context-aware

The system uses RFID implements and sensors to sense user’s diet and parameters of vital single daily. The virtual case study in the below:

Firstly, when user wants to eat food that user can use PDA to connect RFID Reader which can sense user’s diet contents and calorie. And the system will store and record the contents and calorie of food to database server (shown as Fig. 20).

Table. 3. Classification indexes in kNN with CFSM, MO, or LSA

class	kNN			kNN+LSA		
	kNN	kNN+ CFSM	kNN+CFSM +MO	kNN+ LSA	kNN+CFSM +LSA	kNN+CFSM+ MO+LSA
<b>Fruit</b>	21.05%	36.84%	52.63%	42.11%	57.89%	68.42%
<b>Meat</b>	26.32%	42.11%	57.89%	47.37%	57.89%	68.42%
<b>Seafood</b>	68.42%	63.16%	73.68%	57.89%	68.42%	73.68%
<b>Vegetable</b>	42.11%	73.68%	84.21%	73.68%	89.47%	89.47%
<b>Micro- Average</b>	39.47%	53.95%	67.11%	55.26%	68.42%	<b>75.00%</b>



Figure. 20. Food's name and calorie

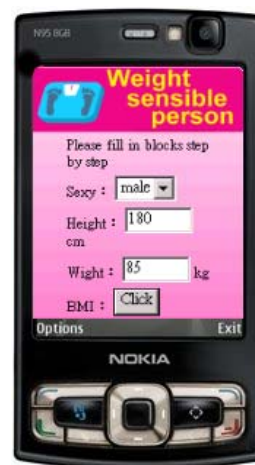


Figure. 21. Computing BMI value

Secondly, this paper designs a weight sensible personal basic data that can input sex, height, and body weight to compute BMI value and daily calorie (shown as Fig. 21). The weight sensible person monitors diet calorie daily, when users eat over the calorie value that will alert on the windows of notice and prevention to users. User's BMI is kept between the standard range, weight sensible person will tell users to carry on weight. Otherwise, the system will recommend users to reduce and control weight.

Thirdly, the system can query user's vital single parameter in exhort nurse function. Users can view own historical healthcare record (BP, BS, temperature etc) by mobile devices. ICFDSS can query and transform to line chart with parameters of ECG/EKG, HR, RR, BP, BS, temperature, and light (shown as Fig. 22).

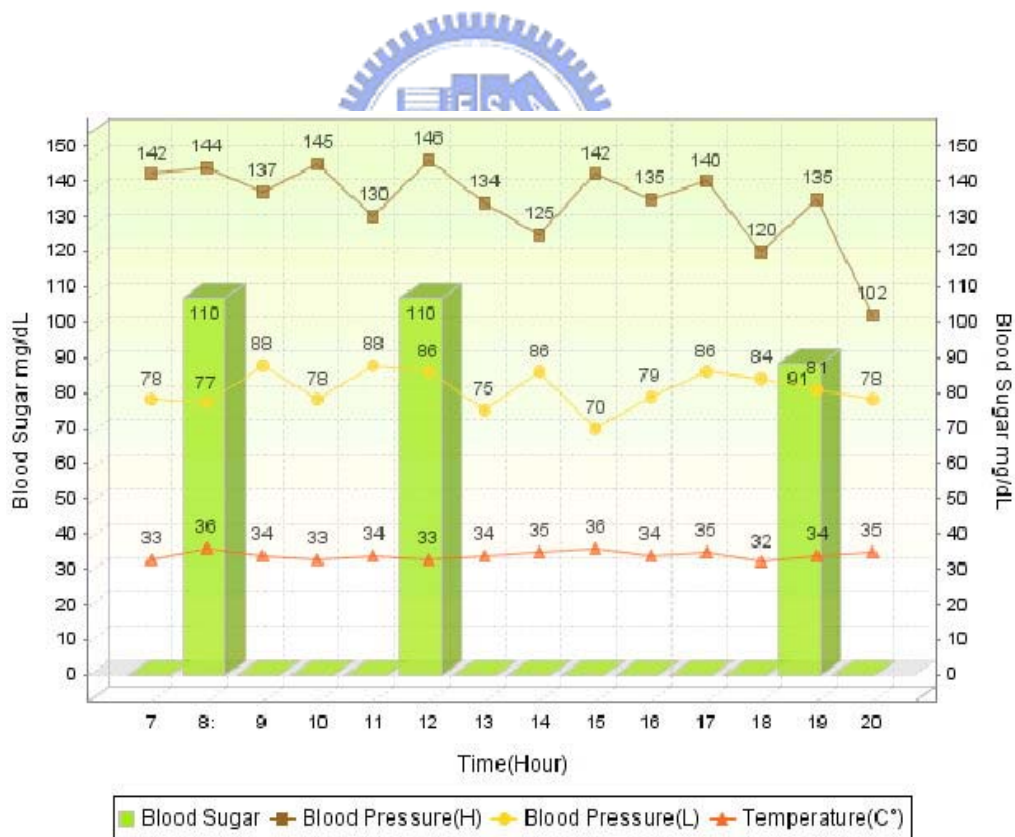


Figure. 22. Parameters of line chart

### 6.3.2.2 The Adaptable Curative Food Service Inference

The CFS reservation as one kind of web services is provided by various kinds of curative food industries on the internet. ICFDSS helps patients to find adaptable CFS for their remedy and eating plans. Generally, users want to find CFS reservation services through UDDI or the current matchmaking for web services. In ICFDSS, the system will recommend adaptable CFS to MUs. The proposed method is shown as Fig. 19 which is applied to solve this problem according to the following procedures:

Step 1: Many curative food industries will provide their CFS reservation services on themselves SOAP site (such as AXIS2) and publish the information of those services which include company name, therapy name, location, and price to UDDIRs based on JUDDI.

Step 2: When MUs inquire the SRA for the adaptable CFS through UIA, they send their requirements as a part of the request.

Step 3~4: The UIA will send the MUs' requirement to URJA. For example, MUs input their infirmities “心臟病, 手腳冰冷, 胃腸功能障礙, 風濕症, 神經衰弱, 高血壓, 腎臟病, 過敏疾病, 慢性疾病, 酸痛, 關節炎” in PC and PDA to request CFS, shown as Fig. 23. URJA supports the processes to include lexical analysis will check and store user's information in Personal Health Record (PHR) for inference user's requirements.

Step 5: The URJA will get user's requirement from UIA and send it to CFSIA. When CFSIA receives the user's requirement inference result from URJA, it will control and coordinate various modules in MBS.



Figure. 23. Request ICFDSS



Figure. 24. Response ICFDSS

Step 6: The SPM will inference user's affinity information by CFSM and MO according to user's requirement from URJA. The text preprocess of SPM can segment the requirement to original word-by-document matrix which will be replaced with concept layer matrix  $Q$  by CFSM, MO, and Term Frequency – Inversed Document Frequency (TF - IDF). For example, the segment “心臟病” of this requirement will be presented the concept “心臟與血管疾病” and matrix  $Q$  is computed by the TFIDF value of the concept “心臟與血管疾病”.

Step 7: To search the adaptable CFS, the ACFSIM will find the adaptable CFS class by LSA and kNN. The kNN will combine the negative influence weight value to calculate the similarity between matrix  $Q$  and trained matrix  $L'$  to get the most similar class, such as “Vegetable”. We can find the adaptable CFS class through above those processes and CFSIA will sent this message to SRA for retrieval related CFS.

Step 8~11: The SRA holds up-to-date information on currently available offers for CFS which has been requested recently. To keep offer lists up-to-date, the SRA inquires the one or more UDDIRs periodically regularly in order to check, find, and get for new offers. When SRA receives the CFS class from CFSIA, it will query the Web Service Cache (WSC) and Geographic Information Database (GID) to get adaptive CFS.

Step 12~13: ICFDSS returns the results and recommends the adaptable CFS to MUs, shown as Fig. 24. If MUs agree this suggestion, ICFDSS will make the CFS reservations automatically.

Step 14: MUs will pay the money to get CFS reservations which are ordered by curative food decision system and get those bills.



## 6.4 Discussion

Recently the developed a few curative food recommendation services mostly focus on single infirmity considered, but they can't support to inference multiple infirmities with therapy. In this research, we propose a Intelligent Curative Food Decision Support Subsystem (ICFDSS), which provides user's requirements inference and relative services, searches by semantic inference engine and finds the most adaptive Curative Food Service (CFS). We discover the accuracy of CFS inference that is higher by combining Curative Food Stemming Mechanism, Medical Ontology, Term Frequency – Inversed Document Frequency, Latent Semantic Analysis, and k-Nearest Neighbor. Mobile users can conveniently obtain customized CFS and decision to use those services according to their health requirement in advance by ICFDSS.

In the future, ICFDSS can be integrated with food schedule according to MUs' diet habit and physiology state for healthiest diet. Otherwise, ICFDSS can also be combine with information appliances (such as RFID-enabled refrigerator) apply to home healthcare for CFS inference.



## **Chapter 7 4D Emergency Indication and Ambulance**

### **Dispatch Subsystem (4DEIADS)**

This research will adopt Embedded Multimedia Communication technology to design the “4D Emergency Indication and Ambulance Dispatch Subsystem (4DEIADS)” which it can overcome the space and time limiting. Users can use the handheld devices with high mobility via wireless network (3G/GPRS/GSM) to get disaster multimedia stream service [50, 70, 71, 76]. In addition, this research also combines Web Services, Customized Services, Location-Aware Service [32], wireless Sensor Network, Multicast, Web GIS [3, 26, 64], Intelligent Agent [45], and Virtual Reality [27], etc. The 4DEIADS transmits the VR of the disaster to the server, and to overcome the space and time limiting with the end-server to exchange information. The 4DEIADS system will automatic to describe the best adaptable escape route, which provides and guides users the escape route and harbor place [36, 77], and monitoring the great natural disaster effectively such as Sediment, floods, earthquake, landslide, forest fire. The 4DEIADS system also provides rescue center to make best decision. The disaster decision is packed as a reusable web services which can be used in 4DEIADS or other systems for reducing the cost and speeding up the efficiency of system development in the future [24 25].

#### **7.1 System Design Principle**

The 4DEIADS includes knapsack problems (KP) adaptable escape path (AEP), flood disaster simulation, and active database which is composes of information database of disaster, geographical information database, and multimedia file database.



### 7.1.1 Knapsack Problems (KP)

When mobile users use RFID technique to send escape path request to 4DEIADS that will choice some safety sanctuaries  $(R_1, R_2, \dots, R_n)$  which have enough medical materials:

4DEIADS choices a safety sanctuary and provides the adaptable escape path according to the user's position and the types of victims of a natural disaster such as defective ( $h_i$ ), ancient ( $o_i$ ), women and children ( $w_i$ ), and commoner ( $o_i$ ). The safety sanctuary ( $R_i$ ) provides limited medical materials ( $m_i$ ) and space ( $s_i$ ):

$$(1) R_i = s_i - a_1 h_i + a_2 o_i + a_3 w_i + a_4 g_i \geq 0, \quad a_i \geq 0$$

(2)  $a_1 h_i \geq 1, m_i > 0$  (If user's type were defective, there would be odd medical materials in the sanctuary.)

$h_i, o_i, w_i$ , and  $g_i$ : the type of victims of a natural disaster

$a_i$ : the number of victims of a natural disaster

4DEIADS combines RFID technique and Knapsack Problems algorithm to infer the adaptable sanctuary.

### 7.1.2 Adaptable Escape Path (AEP)

User can use wireless mobile network to connect model database server in order to carry on the inference of AEP. Model of AEP depend on SPA. The model of AEP offers the shortest path and most smooth route to calculate cost of every section, and the AEP system also help disaster people on different situation.

When disaster happens, rescue persons need to arrive disaster area and handle disaster situation quickly, this system will offer the-shortest path for disaster persons to finish treating and curing work. Every route calculation cost is changed by the longitude and latitude to revise angles and statistic the total cost, and the model combines Digital Topographic Model (DTM) and Euclidean Distance formula to calculate the distance of degree of three-dimension. The formula is as follows

$$ED_i = \sqrt{(X_i - X_{i-1})^2 + (Y_i - Y_{i-1})^2 + (Z_i - Z_{i-1})^2}$$

$ED_i$ : route ( $i$ ), road distance for  $i$  to  $i-1$

$X_i \cdot X_{i-1}$ : longitude change to right angles coordinates for  $i$  to  $i-1$

$Y_i \cdot Y_{i-1}$ : latitude change to right angles coordinates for  $i$  to  $i-1$

$Z_i \cdot Z_{i-1}$ : DTM for  $i$  to  $i-1$

4DEIADS infers the adaptable escape path according to Highway Capacity Manual (HCM) by 3D distance, time stamp, roadway capacity, etc. This study proposes calculating density of sub-route, level of service, operating speed, and 3D distance to infer the adaptable escape path for dispersal of mobile users.

To set roadway capacity stands on “The roadways capacity in Taiwan report” that defined free operating speed as 65 KPH, maximum volume of traffic as 136 CPK, and basic capacity as 2,200 PCPH to calculate level of service, such as A~F by HCM shown as table 4. When disaster occurs, 4DEIADS calculates time-cost through driving sub-route by density and operating speed. The formula is as follows.

$$k = \frac{(V / C) * C_j}{u}$$

The time-cost value will lie between 0 and 100 after standardizing the distance.

The formula is as follows.

$$t_i = \frac{t_i}{t_{Max}} \times 100$$

After finishing standardization, the system uses SPA to calculate reach each route and obtain minimum cost. The formula is as follows.

$$\text{Min } \sum_{i=1}^n t_i, n : \text{Total } n \text{ sub-route}$$

Table. 4. The Basis of Level of Service Estimate

<b>Level of service</b>	<b>Density (car / km, CPK)</b>	<b>Operating Speed (km / hr, KPH)</b>	<b>Volume of traffic /Capacity(V/C)</b>
A	<= 13	>= 65	36%
B	<= 21	>= 59	54%
C	<= 31	>= 54	71%
D	<= 43	>= 43	87%
E	<= 68	>= 32	100%
F	> 68	< 32	> 100%

Table. 5. The- Adaptable Escape Path (AEP)

This algorithm solves the single-source shortest-paths problem on a weighted, directed or undirected graph for the case where all edge weights are nonnegative.

Step 1 :

(a) Let  $S = 0$  and there is no

(b) Let  $L = \{S\}$  and  $k = 0$

Step 2 :

**repeat**

Step 2.1 :

$k = k + 1$

Step 2.2 :

**while**  $V = L(k-1)$

(a)  $W(k-1) = V$

(b)  $L(k) = W(k)$

**endwhile**

**until**

Step 3 : (create a shortest path)

**if** point  $T$  belongs  $L$

Given a connected graph  $G=(S,T)$ , a weight  $d:S \rightarrow T$  and a fixed vertex  $S$ , find a shortest path from  $s$  to each vertex  $V$ .

**otherwise**

There is no path from  $S$  to  $T$ .

**endif**

### 7.1.3 Flood/Debris-flow Simulation

When heavy rainfall cause and bring debris-flow, the original road or even adaptable escape path will be destroyed by flood to let rescue difficulty. Therefore, use sensor network and rainfall information agent to collect information of the disaster area, and the disaster range mark out by producing geographical information agent such as longitude and latitude coordinate and height above sea level to get area. Users will obtain real-time reference and decision, and the system schemes adaptable escape path to avoid disaster area and let user to arrive the safety sanctuary. The study adopts the design of the scale to analyze the virtual position data, and combine the grid data, Convex Hull Algorithm (CH), and Spatial Interpolation Methods (SI) to calculate position data. The DTM data of National Pingtung University Science and Tecnology (NPUST) is as follows Fig. 25.

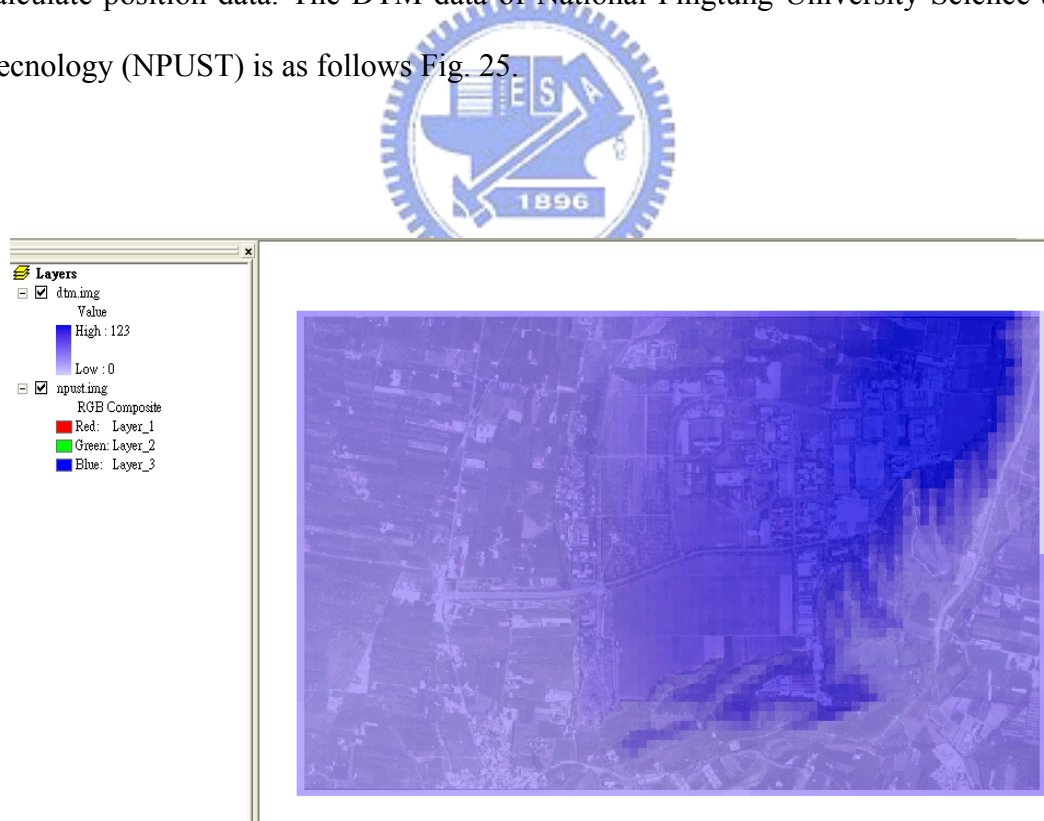


Figure. 25. DTM of NPUST

### 7.1.3.1 Convex Hull Algorithm (CH)

According to the user's position connect to database and get geographical information, then overflow simulation adopts the characteristic of TIN of DTM to judge. The flood points loads to CH in Table 6 to calculate and fast to produce overflow range. The Convex Hull Algorithm is as follows Table 6.

Table. 6. Convex Hull Algorithm (CH)

<p>(1) Get input, <math>N</math> = number of points.</p> <p>(2) <b>Initialize:</b> <i>HullList</i>, <i>EdgeList</i>, <i>PointList</i>.</p> <p>(3) Choose two points, <math>A</math> and <math>B</math>, that form an edge.</p> <p>(4) Choose any point <math>C</math>, not collinear with <math>A</math> and <math>B</math>.</p> <p>(5) Compute cross product <math>N_X = (A - B) * (C - B)</math>.</p> <p><math>X</math> = the plane at <math>B</math> with normal <math>N_X</math>.</p> <p>(6) <b>For</b> every data point (except <math>A</math>, <math>B</math>, <math>C</math>) compute signed distance to plane</p> $\text{distance}(P, X) = (P - B) * N_X$ <p>and find the point, <math>P</math>, with maximum distance.</p> <p>(7) <b>If</b> <math>\text{distance}(P, X) &gt; 0</math>, then <math>C = P</math> and <b>GoTo</b> (6).</p> <p><b>Else</b> I know <math>X</math> is a face plane.</p> <p>(8) Create a face, <math>F</math>, with all data points on the plane <math>X</math>. (This will include <math>A</math>, <math>B</math>, <math>C</math> and possibly others).</p> <p>(9) Sort <math>F</math> points according to <math>\text{angle}(P) = (P - B) * (A - B)</math></p> <p>(10) Add <math>F</math> to <i>HullList</i>.</p> <p>(11) <b>For</b> each edge, <math>E = (P1, P2)</math>, clockwise on the perimeter of <math>F</math> do {</p>
--

$ER = (P2, P1)$ .

**If**  $ER$  is in the *EdgeList* list {

**If**  $E$  is in the *PointList*, remove  $E$  from the *PointList*.

}

**Else** {

    Add  $E$  to the *EdgeList*

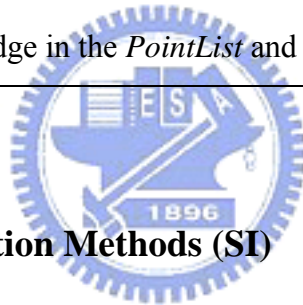
    Add  $ER$  to the *PointList*

}

}

(12) **If** the *PointList* is empty, return the *EdgeList* and *HullList*.

(13) **Else** get  $(A, B)$  the next edge in the *PointList* and **GoTo** (5).



### 7.3.1.2 Spatial Interpolation Methods (SI)

According to user's area connect to database and get geographical information, then the SI model calculate DTM of each position by using the characteristic of TIN of longitude and latitude coordinate and DTM. The reference decision Prevention and rescue persons will obtain real-time reference and decision.

## 7.2 System Architecture and Implementation

4D Emergency Indication and Ambulance Dispatch Subsystem (4DEIADS) is a three-tier system as Fig. 26. It can overcome the space and time limiting. Users can use the handheld devices with high mobility via wireless network (3G/GPRS/GSM) to get disaster multimedia stream service. In addition, this research also combines Web

Services, Customized Services, Location-Aware Service, wireless Sensor Network, Multicast, Web GIS, Intelligent Agent, and Virtual Reality, etc. The 4DEIADS transmits the VR of the disaster to the server, and to overcome the space and time limiting with the end-server to exchange information. The 4DEIADS system will automatic to describe the best adaptable escape route, which provides and guides users the escape route and harbor place [36, 77], and monitoring the great natural disaster effectively such as Sediment, floods, earthquake, landslide, forest fire. The 4DEIADS system also provides rescue center to make best decision. The disaster decision is packed as a reusable web services which can be used in 4DEIADS or other systems for reducing the cost and speeding up the efficiency of system development in the future.

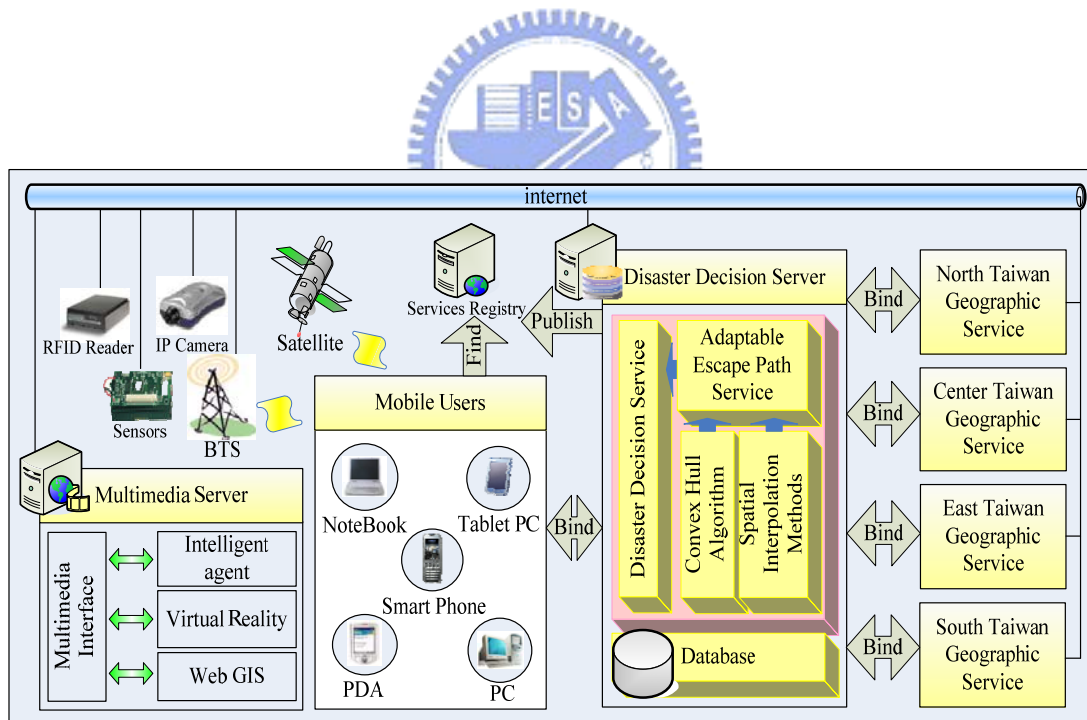


Figure. 26. The architecture of 4DEIADS system

### 7.2.1 Mobile Users (MUs)

Mobile users provide the functions that include (1) Location-Based Service, (2)



Virtual reality of debris-flow, (3) Virtual reality of Adaptable Escape Path (AEP), (4) Alert Flood / Debris-flow disasters information, (5) Prevent multimedia information, (6) Customized Service, and (7) Heterogeneous Networks, etc.

### **(1) Location-Based Service**

Mobile user utilizes the terminal server of handheld device to link the mobile communication network or internet network, to login and use DPI system, and to perform GPS to locate Location-Aware Services automatically. GPS gets Coordinate that utilizes GSM/GPRS mobile-phone to transmit back multimedia server by mobile communication network, then the multimedia server carry on the regional information analysis. This function records every user's position, offers Location-Based Service, and understands the information and location of every user.



### **(2) Virtual reality of debris-flow**

Geographical information system will show 3D virtual reality, link database server to simulate debris-flow, and derive debris-flow simulation area. The reasoning result will produce destruction animation in virtual reality, in order to provide real-time disaster situation to the personnel and user of disaster emergency decision centre to understand the possible disaster.

### **(3) Virtual reality of Adaptable Escape Path (AEP)**

The user use PDA to combine GPS that assists user to proceed Location-Aware Services by the non-space-time restriction, GPRS communication network transfer

accurate position coordinate to model database server or the prevention and rescue center, and the server will stand on the coordinate transmitting to GIS database and analyzing data. The adaptable escape path system describes and points out the route of escape in 3D, and the system informs users which are most suitable route and sanctuary.

#### **(4) Alter Flood / Debris-flow disasters information**

Mobile clients can use various handheld appliances, such as a PDA or tablet PC incorporating a cellular phone, to alter Flood / Debris-flow disasters information.

#### **(5) Prevent multimedia information**

To Design the multimedia database that can transmit characters, pictures, videos, and Audios (Tan, 2004). Mobile clients can use various handheld appliances, such as a PDA or tablet PC incorporating a cellular phone, to transmit and receive multimedia debris-flow information that includes texts, photos, images and audios to provide real-time and interaction communications over heterogeneous networks shown as Fig. 27 and 28.

#### **(6) Customized Service**

While system has user's position system to provide customized services at time, including different devices to offer different pictures, and information of the debris-flow and rainfall in the disaster area. Users will be easier to get relevant disaster information for step by step.



Figure. 27. Disaster picture on PDA



Figure. 28. Multicast meeting on PDA



Figure. 29. Sensor searching on PDA

## (7) Heterogeneous Networks

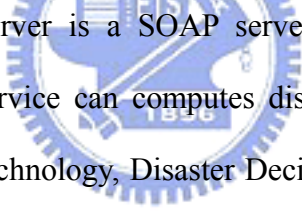
Users utilize the different network protocol, so the design of system lets the terminal device or mobile equipment that can be integrated services such environments as GSM, GPRS, wired network, IEEE802.11x wireless network, etc..

### 7.2.2 Multimedia Server (MS)

The designed Multimedia server is composed of (1) Intelligent Agents: that intelligent agent system includes: (i) Sensor network monitor agent (SNMA), (ii) Rainfall information agent (RIA), (iii) News Agent (NA), (iv) Geographical information agent (GIA), (v) The user interface agent (UIA), (vi) Coordinating agent (CA), and (vii) Resources monitor agent (RMA). (2) Virtual Reality of Multimedia: is to design Virtual reality of multimedia to let users monitoring in the disaster area, and

disaster prevention expert can use relevant topographic maps and virtual disaster simulation to analyze disaster situations in any areas shown as Fig. 29. Due to VRML language have more little file format that is good for relevant disaster files and simulation situations to upload and download using 3G/GPRS. (3) Web GIS: Web GIS is similar to web mapping with an emphasis on analysis, processing of project specific geo-data and exploratory aspects. Web maps are often a presentation media in web GIS, and web maps are increasingly gaining analytical capabilities. A special case of web maps are mobile maps that display on mobile computing devices, such as mobile phones, smart phones, PDAs, GPS, and other devices.

### **7.2.3 Disaster Decision Server (DDS)**



The disaster decision server is a SOAP server which provides the Disaster Decision Service, and this service can compute disaster escape paths for MUs in real-time. By Web Services technology, Disaster Decision Service can be used in not only 4DEIADS but also any other disaster systems (no matter what the programming languages of those systems are). For this reason, the disaster escape route decision is needless to re-develop and re-design, and it will be frugal of the cost of disaster program development. On the other hand, if some bugs are appeared of this service, programmers only need to fix this service and without to modify client's program. Therefore, the disaster programs will be as loosely coupled as possible in the future.

Mobile users can input the overflow height to model base server of 4DEIADS, and to choice rapid CH or accurate SI to simulate disaster areas. To reduce the network bandwidth consumption and adapt to the computing capability of the mobile appliance, 4DEIADS only transmits the coordinate values and the differences in the

media objects to the mobile appliance. Mobile users can choice “The Adaptable Escape Path Model” to infer the AEP with situation-aware information. 4DEIADS has the function of flight simulation in the virtual reality and provides the rescue center and people to search the escape path as Fig. 30.



Figure. 30. AEP of flood simulation in VR

### 7.3 Discussion

In this research, we developed a 4DEIADS in SOA, which provides the occurrence probabilities of debris-flow and flood disasters in Pingtung county or Taiwan, the real-time multimedia communications bases on mobile environments, and a flexible disaster system design idea. The development of disaster systems could be as loosely coupled as possible to decrease the cost of system designed by using Web services and SOA concept. Mobile node could use all kinds of handheld devices to

transmit and receive the multimedia information between the disaster area and the rescue-control center. Mobile user can conveniently obtain customized information and decision to prevent the occurrence of disaster in advance.

However, the 4D Adaptable Escape Path inference is based on real-time traffic information from DDS. 4DEIADS only focus now on vehicle communication to collect and integrat a large amount of real-time traffic information, and DDS will have heavy-loading computing. Therefore, 4DEIADS can be integrated with Cellular Floating Vehicle Data (CFVD) or Floating Car Data (FCD) technology to be supported.



## Chapter 8 Conclusions and Future Work

This thesis emphasizes the issues related to the most adaptive Nature Medicine Services (NMS) inference using semantic web technology. This chapter summarizes our studies, and briefly discusses directions of the future work.

### 8.1 Summary

Recently there has a few medical tourism systems developed which mostly focus on location-aware service but no medical tourism service recommendation in Taiwan. In this research, we proposed a Ubiquitous Context-aware Healthcare Service System (UCHS), which provides user's requirements inference and relative services search by semantic inference engine and find the most adaptive NMS. We discover the accuracy of the NMS inference is higher by combining Medical Stemming Mechanism (MSM), Medical Ontology (MO), Term Frequency – Inversed Document Frequency (TF - IDF), Latent Semantic Analysis (LSA), and k-Nearest Neighbor (kNN). Mobile users can conveniently obtain customized NMS and decision to get and use those services reaching the target “Eat, Drink, and Be Merry with Health” in advance by UCHS.

### 8.2 Future Work

In the future, the MO can be modified to store more levels of medical tourism and other domain knowledge for UCHS. For requirement classification, the similarity is computed by different level of MO to get adaptable NMS from different industries. Otherwise, we can analysis the market requirement with questionnaire survey and discuss about healthcare law and policy to be promoted.

## References

- [1] A. K. Dey and G. D. Abowd, "Towards a Better Understanding of Context and Context-awareness", In Proceedings of the CHI 2000 Workshop on the What, Who, Where, When, Why and How of Context-awareness, 2000, pp. 1-6.
- [2] B. H. Zeng, M. H. Yao, Z. Y. Jia, X. C. Chen, Y. C. Lai, Y. C. Liang, "General Packet Radio Service of GSM mobile communication network : Introduction of GPRS", TL Technical Journal, Vol. 31, No. 1, 2001.
- [3] B. X. Shi, "Geographic Information System", Scholars Books, Taipei, 2000.
- [4] C. C. Liu, J. Y. Yeh, H. R. Ke, W. P. Yang, "A concept extraction approach for document clustering", In Proceedings of the Conference on Computational Linguistics and Speech Processing, Tainan, Taiwan, 2005.
- [5] C. C. Lo, C. H. Chen, H. T. Kao, C. C. Lu, D. Y. Cheng, "Research on Developing Healthy-life Map Guiding System", In Proceedings of the 6th International Conference on Service Systems and Service Management, Xiamen, China, 2009.
- [6] C. C. Lo, D. Y. Cheng, C. H. Chen, "A Semantic Web Methodology for Situation-Aware Curative Food Service Recommendation System", In Proceedings of the IEEE International Conference on Computer Science and Software Engineering 2008, Wuhan, China, 2008.



- [7] C. C. Lo, D. Y. Cheng, C. H. Chen, J. S. Yan, "Design and Implementation of Situation-Aware Medical Tourism Service Search System", In Proceedings of the 4th IEEE International Conference on Wireless Communications, Network and Mobile Computing, Dalian, China, 2008.
- [8] C. C. Lo, D. Y. Cheng, C. H. Chen, Y. J. Lu, C. M. Chen, "Design and Implementation of an Intelligent Medical Tourism Service Recommendation System", Journal of Information Management, Vol. 16, 2009, pp. 131-152.
- [9] C. M. Huang, C. I. Yang, L. F. Chu, "A Study of a Chinese-English Web Document Summarization", In Proceedings of the 7th Information Management Practice, Taipei, Taiwan, 2001.
- [10] C. M. Huang, C. I. Yang, L. F. Chu, "Evaluation on TFIDF and GBP Approaches for Content-Representative Sentences Extraction", In Proceedings of the 13th International Conference on Information Management, Taipei, Taiwan, 2002.
- [11] C. M. Huang, Y. Y. Wu, "Automatic Web Structuring and Summarization for Chinese Text", In Proceedings of the Taiwan Network Conference 1999, Kaohsiung, Taiwan, 1999.
- [12] D. Dressen, "Consideration for RFID Technology Selection", Atmel Applications Journal, 2004, pp.45-47.
- [13] D. H. M. Tan, S. C. Hui, C. T. Lau, "Wireless messaging services for mobile users", Journal of Network and Computer Applications, Vol. 24, No. 2, 2004, pp. 151-166.

- [14] D. Janssen, A. Lins, T. Schlegel, M. Kühner, and G. Wanner, “A Framework for Semantic Web Service Retrieval”, In Proceedings of the 3rd Nordic Conference on Web Service, 2004, pp. 1-14.
- [15] D. R. Radev, A. Winkel, and M. Topper, “Multi Document Centroid-based Text Summarization”, In Proceedings of the ACL-02 Demonstration Session, Pennsylvania, US, 2002.
- [16] D. R. Radev, H. Jing, M. Budzikowska, “Centroid-based summarization of multiple documents: sentence extraction, utility-based evaluation, and user studies”, In Proceedings of the ANLP/NAACL 2000 Workshop on Automatic Summarization, 2000, pp. 21-29.
- [17] D. R. Radev, T. Allison, S. Blair-goldensohn, J. Blitzer, A. Çelebi, S. Dimitrov, E. Drabek, A. Hakim, W. Lam, D. Liu, J. Otterbacher, H. Qi, H. Saggion, S. Teufel, A. Winkel, Z. Zhang, “MEAD - a platform for multidocument multilingual text summarization”, In Proceedings of the 4th International Conference on Language Resources and Evaluation, Lisbon, Portugal, 2004.
- [18] D. R. Radev, V. Hatzivassiloglou, and K. R. McKeown, “A description of the CIDR system as used for TDT-2”, In DARPA Broadcast News Workshop, Herndon, VA, 1999.
- [19] Executive Yuan in Republic of China (Taiwan), “Industrial Manpower Package for Three-year Head-start Project of Taiwan’s Economic Development Visions for 2015”, 2006.
- Available: <http://www.ey.gov.tw/np.asp?ctNode=445&mp=1>

- [20] G. Erkan and D. R. Radev, "LexPageRank: Prestige in Multi-Document Text Summarization", In Proceedings of the EMNLP 2004, Barcelona, Spain, 2004, PP. 365-371.
- [21] G. Pang, and Poon G., "A Portable Multimedia Information Device in a Wireless Optical Data Link", IEEE Transactions on Consumer Electronics, Vol. 47, 2001, pp. 87-95.
- [22] G. Salton and M. McGill, "Introduction to modern information retrieval", McGraw-Hill, New York.
- [23] H. Y. Kung and C. Y. Lin, "Application-Layer Context-Aware Services for Pervasive Computing Environments", In Proceedings of the 1st International Conference on Innovative Computing, Information and Control, Beijing, China, 2006.
- [24] H. Y. Kung, C. I. Wu, C. H. Chen, Y. H. Lan, "Using RFID Technology and SOA with 4D Escape Route", In Proceedings of the 4th IEEE International Conference on Wireless Communications, Network and Mobile Computing, Dalian, China, 2008.
- [25] H. Y. Kung, K. J. Tsai, H. H. Ku, M. S. Lin, C. I. Wu, "Wireless Communication Systems Applied on the Assessment of Debris Flow Disaster Prevention and Alert", In Proceedings of the Third Mountain Disasters and Environmental Protection across China Strait Conference, Vol. 3, 2002, pp500-508.

- [26] J. G. Lai and H. H. Wang, "A comparative study on the interpolation of digital contours", Geographical Journal of Department of Geography on NTU, Vol. 21, 1996, pp. 83-94.
- [27] J. Gradedki, "The Virtual Reality Construction Kit", John Wiley and Sons, New York, 1994.
- [28] J. Han and M. Kamber, "Data mining: concepts and techniques", San Diego, CA: Academic Press.
- [29] J. Kupiec, J. Pedersen, and F. Chen, "A Trainable Document Summarizer", In Proceedings of the 14th Annual International ACM/SIGIR Conference on Research and Development in Information Retrieval, Seattle WA, USA, 1995.
- [30] J. Stankovic, Q. Cao, T. Doan, L. Fang, Z. He, Kiran R., Lin S., Son S., Stoleru R., and Wood A., "Wireless Sensor Networks for In-Home Healthcare: Potential and Challenge", In Proceedings of workshop on High Con dence Medical Device Software and Systems, 2005.
- [31] J. W. Fan and C. Friedman, "Semantic Classification of Biomedical Concepts Us-ing Distributional Similarity", Journal of the American Medical Informatics Asso-ciation, Vol. 14, No. 4, 2007, pp. 467-477.
- [32] J. X. He, "A brief introduction of GPS", Industry Research and Technology Quarterly, Vol. 129, 1999, pp.76-P81.

- [33] J. Y. Yeh, "A study on automated text summarization and its application on Chinese documents". Master Thesis, Department of Computer and Information Science, National Chiao Tung University, Hsinchu, Taiwan, 2002.
- [34] J. Y. Yeh, H. R. Ke, W. P. Yang, and I. H. Meng, "Text summarization using a trainable summarizer and latent semantic analysis", *Information Processing and Management*, Vol. 41, 2005, pp. 75-95.
- [35] J. Z. Feng, "Introduction to Operations Research," 7th edition, Tsang Hai Book Publishing, 2000, pp. 393-414.
- [36] K. I. Tai, "Studies in the major disaster crisis management of local governments - Take the examples of the CAL Tao-Yuan air crash and the Tao-Chi typhoon disaster", Master Thesis, Department of Institute of Public Administration, National Dong Hwa University, 2003.
- [37] K. Kaikhah, "Text Summarization Using Neural Networks", *WSEAS Transactions on Systems*, Vol. 3, No. 2, 2004, pp. 960-963.
- [38] L. Aalto, N. Göthlin, J. Korhonen, T. Ojala, "Bluetooth and WAP Push Based Location-Aware Mobile Advertising System", In *Proceedings of the 2nd international conference on Mobile systems, applications, and services*, 2004, pp. 49-58.
- [39] L. L. Yen, "Establishment of Flood Effect Data Upload and Analysis System", Master Thesis, Department of Geography, National Taiwan University, 2001.

- [40] L. W. Ku, Y. T. Liang, and H. H. Chen. “Opinion extraction, summarization and tracking in news and blog corpora”, In Proceedings of the AAAI-2006 Spring Symposium on Computational Approaches to Analyzing Weblogs, 2006, pp. 100-107.
- [41] Lietu Search –automated summarization online, Lietu Enterprise Search.  
Available: <http://lietu.com/demo/Summary.jsp>
- [42] M. B. Blake, A. L. Sliva, M. Z. Muehlen, and J. V. Nickerson, “Binding Now or Binding Later: The Performance of UDDI Registries”, In Proceedings of the 40th Annual Hawaii International Conference on System Sciences, Hawaii, USA, 2007, pp. 171-177.
- [43] M. R. AMINI, “Interactive Learning for Text Summarization”, In Proceedings of the PKDD'2000 Workshop on Machine Learning and Textual Information Access, 2000.
- [44] M. Tian, A. Gramm, H. Ritter, and J. J. Schiller, “Efficient Selection and Monitoring of QoS-aware Web Services with the WS-QOS Framework”, In Proceedings of the IEEE/WIC/ACM International Conference on Web Intelligence, Beijing, China, 2004, pp. 152-158.
- [45] M. Wooldridge, “This is MyWorld: the logic of an agent-oriented testbed for DAI, In Intelligent Agents: Theories, Architectures and Languages”, LNAI, 890, 1995, pp. 160-178.
- [46] Medical Tourism Guide, “Medical Tourism”, 2007.  
Available: <http://medicaltourismguide.org/benefits/>

- [47] N. Eric, L. Greg, “Understanding SOA with Web Services”, Independent Technology Guides, 2005
- [48] N. Ishii, T. Murai, T. Yamada, and Y. Bao, “Text Classification by Combining Grouping, LSA and kNN”, Computer and Information Science, 2006 and 2006 1st IEEE/ACIS International Workshop on Component-Based Software Engineering, 2006, pp. 148-154.
- [49] O. Lassila and J. Hendler, “Embracing Web 3.0”, IEEE Internet Computing, Vol. 11, No. 3, 2007, pp. 90-93.
- [50] R. G. Cheng, “Applications of SMS, HSCSD, and GPRS”, Communication magazine, 1999, pp. 61–65.
- [51] R. Vahidov, “Intermediating user-DSS interaction with autonomous agents,” IEEE Transactions on Systems, Man and Cybernetics, Part A, Vol. 35, Issue 6, 2005, pp. 964-970.
- [52] S. Asghar, A. Alahakoon, L. Churilov, “A hybrid decision support system model for disaster management”, In Proceedings of the 4th International Conference on Hybrid Intelligent Systems, 2004, pp. 372-377.
- [53] S. G. Shi, “Preliminary research of network virtual reality establishing two-dimentional pictures to re-utilize”, Master Thesis, Department of Civil Engineering, Naional Chiao Tung University, 2001.

- [54] S. H. Myaeng, and D. jang, “Development and Evaluation of a Statistically Based Document System”, In I. Mani and M. May bury (eds), Advances in Automated Text Summarization, MIT Press, 1999, pp. 61-70.
- [55] S. J. Zhu, “Designing the disaster information system based on GIS - SARS epidemic situation news as an example”, Master Thesis, Institute of Information Management, National Chiao Tung University, 2003.
- [56] SOHO’s Medical Directory,  
Available: <http://www.sogou.com/c008/c008002.html>
- [57] T. Efraim and E. A. P. Jay, “Decision Support System and Intelligent System,” 5th ed., Hall, 1998.
- [58] T. Y. Chou, “Theory and Practice on Geographic information system,” Scholars Books, Taipei, 2001.
- [59] The E-government Entry Point of Taiwan. Government Information Office.  
Available: <http://webcam.www.gov.tw>
- [60] Tim Berners-Lee, “Information Management: A Proposal”, CERN, March 1989.
- [61] V. T. Esaú, V. P. Luis, and M. Y. G. Manuel, “Using Word Sequences for Text Summarization”, Speech and Dialogue, Vol. 4188, 2006, pp. 293-300.
- [62] W. A. David, A. B. Leonard, and M. Tucker, “Supporting Conversational Case-Based Reasoning in an Integrated Reasoning Framework”, Navy Center for Applied Research in Artificial Intelligence, 1998.





- [63] W. Kraaij and R. Pohlmann, "Porter's stemming algorithm for Dutch, in Noord-man, L.G.M. and de Vroomen W.A.M. (Eds), Informatiewetenschap, Wetenschap-pelijke bijdragen aan de derde STINFON Conferentie, 1994, pp. 167-180.
- [64] W. L. Weng, "Standard overview of geographic information system," Academia Sinica Computing Centre Communication 13, Vol. 19, 2003.
- [65] W. S. Roy, V. N Yefim, "Service Oriented Architectures", Gartner group, 1996.
- [66] W. Y. Ma and K. J. Chen, "Introduction to CKIP Chinese word segmentation system for the first international Chinese Word Segmentation Bakeoff", Annual Meeting of the ACL, In Proceedings of the second SIGHAN workshop on Chinese language processing, Vol. 17, 2003, pp. 168-171.
- [67] Wan Fang Hospital, "Fashion of Medical Tourism", 2007.  
Available: [http://www.wanfang.gov.tw/family/astm/know\\_3.htm](http://www.wanfang.gov.tw/family/astm/know_3.htm)
- [68] X. Geng, R. D. Gopal, R. Ramesh, and A. B. Whinston, "Scaling Web Services with Capacity Provision Networks", Computer, Vol. 32, No. 11, 2003, pp. 64-72.
- [69] X. J. Huang, "Application of information technology based on medical industry", In Proceedings of the International Symposium on Healthcare Information Management, 2000, pp10- 15.
- [70] Y. B. Lin and A. C. Pang, "Wireless and Mobile All-IP Networks", John Wiley and Sons, New York, 2005.

- [71] Y. B. Lin, and C. Imrich, "Wireless and Mobile Network Architectures", John Wiley and Sons, New York, 2001.
- [72] Y. Ko, S. Park, J. Seo, and S. Choi, "Using classification techniques for informal requirements in the requirements analysis-supporting system", *Information and Software Technology*, Vol. 49, 2007, pp. 1128-1140.
- [73] Y. Q. Tu, "Application and practice of investigation of the damage pipeline after the earthquake", Master Thesis, Department of Civil Engineering and Disaster Prevention, National Taipei University of Technology, 2002.
- [74] Y. Xiao, X. Shen, B. Sun, and L. Cai, "Security and Privacy in RFID and Applications in Telemedicine", *IEEE Communications Magazine*, Special issue on Quality Assurance and Devices in Telemedicine, 2006, pp. 64-72.
- [75] Z. Chen, L.T., Chia and B. S. Lee, "DAML-QoS Ontology for Web Services", In *Proceedings of the IEEE International Conference on Web Services*, Washington, DC, USA, 2004, pp.472-479.
- [76] Z. M. Chen, Y. D. Lin, "How GPRS combines GSM and Internet", *Communication Magazine*, 1999, pp. 69-77.