MENTAL CLONING BASE VIRTUAL DIAGNOSTICIAN SYSTEM

Virtual Medical Doctor System (VDS) Reasoning

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Abstract: Human computer Interaction based on emotional modelling and physical views, collectively; has been investigated and reported in this paper. Two types of ontology have been presented to formalize a patient state: mental ontology reflecting the patient mental behaviour due to certain disorder and physical ontology reflecting the observed consequences of such disorder. These two types of ontology have been mapped and aligned for reasoning purposes. We have constructed an integrated computerized model which reflects a human diagnostician as computer model and through it, an integrated interaction between that model and the real human user (patient) is utilized for 1st stage diagnosis purposes. The diagnostician knowledge has been utilized through UMLS for testing, and the integrated mapping of the two views been represented through OWL framework. The reasoning instantiation is done using Description logic. We have implemented the system and empirically, examining it, for revision and evaluation.

1 INTRODUCTION

There have been extensive move towards changing the way health care is delivered, financed and regulated (Smith, 20009) Medical innovations have become an important lever inquest of improving efficiency. The main purpose is to improve the efficiency so that more patients could receive treatment more quickly without reducing the quality of care (Mikkola, 2003). How to cope with a rise in the need for the elderly care services is a formidable issue facing all the industrialized countries.

Unfortunately, Japan's health care system has not been prepared enough to respond to the needs ahead. Particularly Japan's home care services have heavily been relying on voluntary labour of family members with little social services available. The proportion of the population 65 and over has doubled from 10% in 1985 to 20% in 2005, and is projected to be 30% in 2023 (2006, NIPSSR).

In June 2006, the Diet (Japanese Congress) passed a comprehensive package of reform to make the delivery system more efficient. First, the average length of stay in hospitals is to be decreased. To achieve this goal, the number of long term care (LTC) hospital beds will be reduced from the 2006 level of 380,000 to 150,000 by the end of fiscal year 2011 and converted to LTC Insurance facility beds and assisted living (Leflar, 2005). The system proposed in this paper participates in helping physicians to manage the diagnosis procedure using the same knowledge that that physicians have by copying (mimic) his/her style, mentality, diagnosis routines and medicine recipes. It is not replacing the physicians but it would participate to utilize his/her

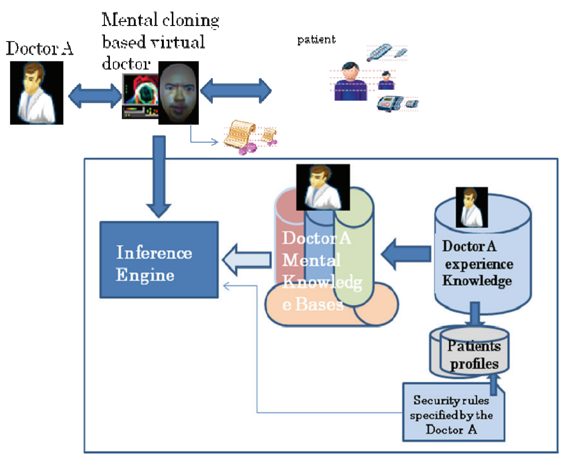

Figure 1: Simple outline of the VDS.

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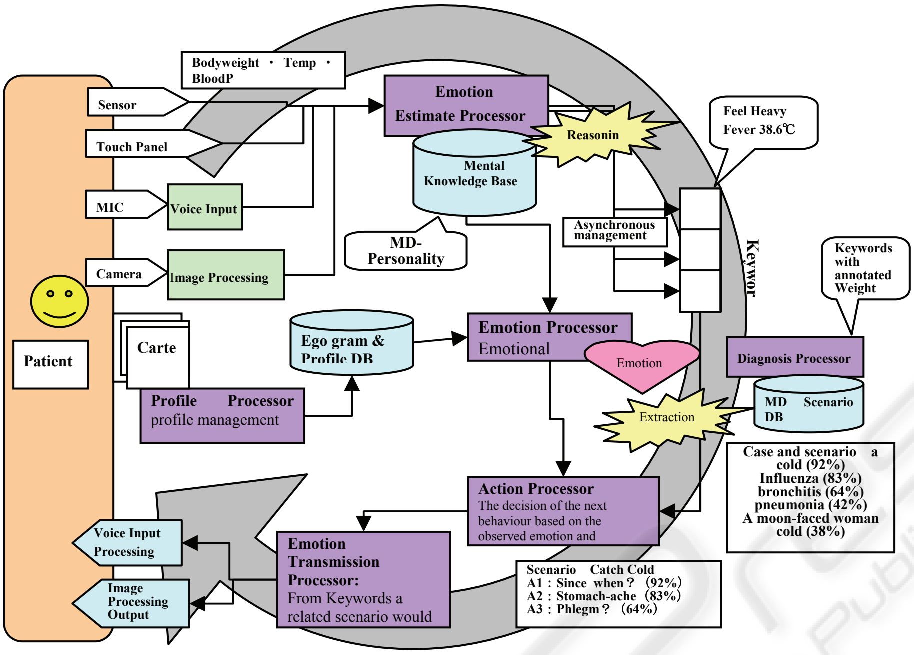

Figure 2: The VDS outline.

knowledge for preliminary diagnosis and health care services for patient for efficiency purpose.

This paper contributes to present part of our experimental work on building a virtual system based or what we called as Virtual doctor System (VDS) Fig.2, to act as a physical or medicinal doctor for diagnosis purposes. In other paper we have presented the outline of the interface, and in this complementary part we are presenting the inference engine and the ontological integration as in Fig.5.

1.1 System Conceptual Outline

The system we called here as VDS (Virtual Medical Doctor) (Fig.2) is to work together with the corresponding medical doctor. So the system (VDS) and the MD are working together in comprehensive coherency; the former is complementary to the latter but not vice versa. The former is to diagnose outpatient 1st and classify these diagnosis into classes. *Simple* cases classes that the VDS would take conclusion and set the diagnosis procedure and accordingly take action (e.g., issue drugs to the patient). The overall procedure is supervised by the medical doctor later on in a report. There are other cases which the system concludes to have the MD to participate in the final decision. In such cases, the system sends the diagnosis reports to the MD and provides an appointment to the patient in the

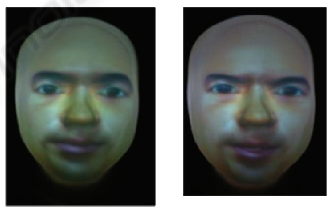

Figure 3: VD avatar.

Figure 4: VDS experiment style.

hospital queue. The system reads the queue data at the management centre of the hospital reception. And assign the patient to the queue. If the Doctor found the assignment is appropriate (check mark *OK*) then the system learned that the decision is appropriate, however, by certain feedback from the doctor the system can learn from the doctor's feedback. We provide a window at the doctor office

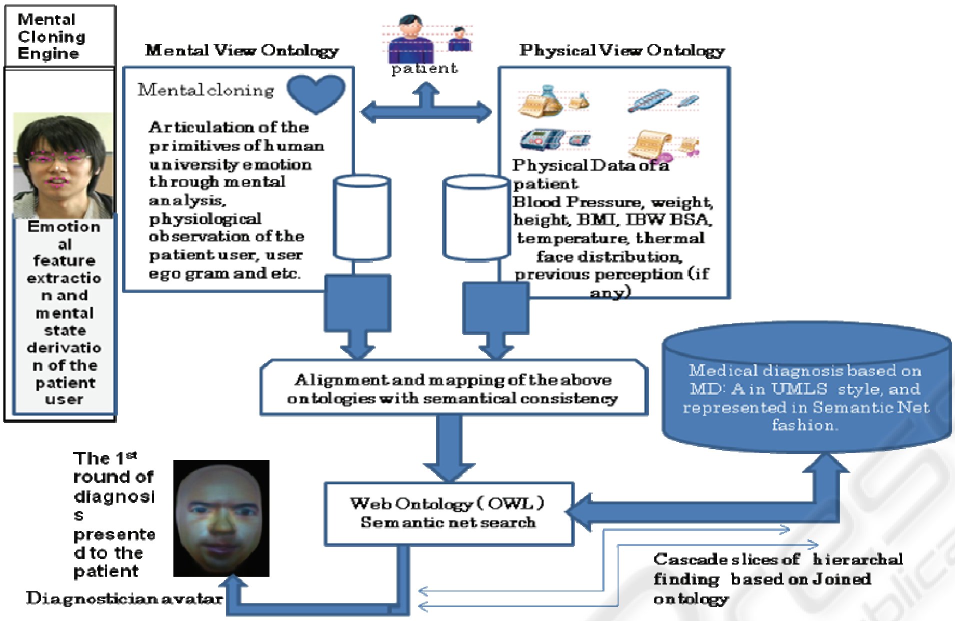

Figure 5: System architecture of the inference engine.

to fill a sheet of evaluation to enforce the learning procedure for the system. Such evaluation sheet would provide a learning mechanism to increase the reasoning procedure for the diagnosis. However such knowledge management would be based (*i.e., mimic*) on Medical Doctor A, therefore, it would be stored in knowledge management on the top of the management system. So when another doctor is doing the outpatient diagnosis then the profile of decision making related to that Doctor would be used (i.e., recalled). So there is a general diagnosis and on top of it there are diagnosis categorized on physicians actual practices.

The paper is showing the state of art in making a system that can interact with human user based on new concept named as mental cloning at (Fujita 2009). The cloning is based on analysis of human medical doctor (HMD). The analysis is projected using his/her observed styles as a person and also as expert in medical diagnosis related practices. So there are different style of categorized knowledge reflecting such representation and related reasoning. As shown in Fig.2 and Fig.3. The system would create a virtual face (i.e., screen mask) of an actual doctor that through it the patient communicates with pre-assigned virtual version of that medical doctor. Physical doctor face is masked copied and attached on manikin (as shown in Fig 4). Inside it there is a projector that reflects the 3 dimensional generated images on the mask screen that reflects the actual facial real-time created images and voices of the medical doctor namely, Doctor A (Fig. 4). These animated facial image synchronized with a spoken language in the same manner as the actual physical doctor is doing diagnosis practices in Japanese hospital. The style mimics the actual doctor emotional expression as well his/her diagnosis Case and scenario a cold (92%) influenza (83%) bronchitis (64%) pneumonia (42%) a moon-faced woman cold (38%) style (Fig.2). Also, the MD would speak in natural accent with emotions based on the patient mental mode, estimated by the patient profile (age, gender, ego data), and his/her situation automatically measured by data resembles (blood pressure, body weight, body temperature, and thermal analyzer).

These devices (equipments) are assembled to a patient desk chair that the patient would sit on, and automatically these measurements are collected and transferred through serial connection to the virtual doctor system. These physical data are all measured and send online to the VDS together with the mental status data (situation) of the user (patient), with estimated ego state retrieved from the databases.

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2 VIRTUAL DOCTOR SYSTEM REASONING ENGINE

The paper reports here, part of our project outcome that is related to interaction between VDS avatar and Patient. The voice recognition issues is been also, discussed in (Kurematsu, 2009). The action scenario is to create a diagnosis based on the guidelines given by the Doctor A. Doctor A is a nominated Doctor which is the object system would mimic to interact with patient through VDS avatar. Implementing medical guidelines of Doctor A in active computer-based decision participates to enhance the best practices of medical services on behalf of Doctor A. Our system reported here briefly, participates to provide cognitive interaction between real patient and specialized doctor A (avatar) through computer interpretable guidelines (CIGs). We have used UMLS Metathesaurus® for testing purposes (Fig.5). The contextualization of the two ontologies specified namely, by the mental ontology and physical ontology annotated mapping alignment, that produce annotated search profiling in the medical knowledge base Unified Medical Language System (e.g.,UMLS) semantic net. We think this is compatible with vocabularies and classification used in patient diagnosis. The combined usage of the two ontologies is intended (Fig. 5) to derive semantically appropriate reference to the patient's status and correspondingly the appropriate concluded aligned key words for relative diagnosis search. The diagnosis retrieval from the knowledge base (i.e., UMLS) would be related to the specialization of the patient case through the combined ontology. This in turn would lead to derive the validated correspondence related to patient condition.

We define the structure of classes that are to be used in the hospital *Class patient*: as the class that specify all types of patient in hospital class and can be attributed by their: *Unique assigned number*; The number can have a structure representing a form that store the profile of that patient and retrieve it when necessary, and to update it is content. This code represents the hierarchy of the data structure of patient ID.

The patient ID file would have information related to the, personal information, like name, gender, age, employment type, tallness, address, marital status, special information and other type of personal related medical information. This also would represent the *patient module* that would have related information to the *mental state* of that patient, his/her *physiological* state definition (Fujita, 2009). This would to establish a template that also stored as part of the patient module structure. Templates related to mental cloning issues. Like the user ego gram, his/her universal templates, and six basic templates of Ekman emotion and the neutral state (no emotion recognized state) (Fujita, 2008). As part of the language issues we have defined other modes that are needed during the diagnosis procedure. These types of emotional modes are related to the effect produced due to a certain combination that the patient would have as a result of disorder or sickness of different cause or nature. These states can be specified as pain(x), x would be a percentage values that to be extracted from the combination of other observed cognitive state. We have six primitives' cognitive states. {*Happy, sad, disgust, fear, surprise, anger*}. Each state can be attributed with a value represents the grades among *high, low medium*. These are primitive's states, due to their characteristic nature to express human emotion, universally. Albeit, the degree of exposing these states are different among people due to several factors. These factors can be predicated and estimated (i.e., computed) based on specialization and symmetrical projection through people characteristic, observed through other disciplinary, like Type_Age, Type_Gender, Type_Ego-gram and so (Hakura, 2009). In this paper, we call these as *stereo data* as typed meta data related to complex representation for emotional states. [Such presentation would be useful to use object orientated technology in the implementation.] For example: TypeFear:(Type_Age:20th, Type_Gender:male, Meta_Type_perosnality). This is a stereo type (i.e., class definition) on Class:fear be characterized. For sickness related issues, the pain (user) can be a stereo type of a combination of {disgust (medium), (sad (low)), neutral}. The combinations of the emotional related states can be extracted in real-time from the frame video collected from user images labeled on the spoken sentences that he/she articulate to present his/her condition. This articulation representation would be to express user physical status or/and mental status using informal representation in spoken language. This time the spoken language is Japanese. As a spoken language it would be arbitrary set of sound words (spoken words). The sound is a stereotype collecting the emotional feature of the patient (i.e., user). (Kurematsu, 2009). The facial and related situational information collected by the system would reflect the status of the patient. Here, is the stereotype of the emotion of the user. So the user status is a combination of the pair: {StereoType_Voice(pitch, power), Stereotype_ (face(happy, sad,..), situation (gender(Boolean), temperature(integer), blood pressure(integer,integer), BMI(integer))}. These two different ontology stereotype information represent the mental cloning of the user for reasoning purpose. The wording (key word extraction by the mapping alignment between the two view schemata related to the two ontologies), are to be concluded by the system. These wording would construct the situation related abstraction useful to be articulated to construct the schema needed to establish the conceptual view of the user diagnostic situation. Words collected from user (i.e., patient) and conceptualized. For example Headache; as a concept is conceptualized into mental view, and physical view. Each view would have a set of condition and assertion to be fulfilled collectively as assertions. This is a temporal order related situational reasoning based on integrated views of reasoning. It is sequent cascade incremental reasoning, based on regenerative schema at the functional correspondence mapping. It is cyclic iterative reasoning based on the same schema's structure for diagnosis. The 1st schema structure would be used to collect the best response, and accordingly the related diagnosis is fetch and customized with diagnostician template to readout, to the patient with emotion mimicking the MD namely A. The response from the patient would lead to another incremental schema that is semantically consistent with the previous schema with similar partial set semantically consistent fragmented diagnosis outcome, with extra key word, extracted from the patient response derived from patient performance due to the readout, role-act diagnosis initiated by the schema of the alignment of the two ontologies. The incremental schema generation from the mapping alignment constructed through the patient and computed by system due to the VDS generated scenarios derived from the semantic net (UMLS), and shown in Fig. 5, is cascading and incremented schema type generation, in nature. This would provide structured interoperability through such integration.

Medical diagnosis process is built by merging a set of fragments instances of the mental views instances with the corresponding physical views instances. These mappings are expressed with various relationships between classes in the two different ontology fragments, for machine executable medical diagnosis purposes.

The VDS final conclusion on the diagnosing situational reasoning process would also be part of the readout to validate the patient performance if he/she is satisfied with the outcome. This validation process is essential to help the patient be more interacted with the VDS on basis on collective engagement for best practices. All diagnosis reports are also sent to the MD for conformance checking.

Above we have expressed the stereotype emotion, and below we integrate it with the stereotype voice. The stereotypes voice is also used by the VDS to express the question and related responses for information extraction from the patient user. The VDS doctor would express these synchronized stereo types using avatar which is 3D generated graphics and synchronized voice sounds as shown in Fig. 2 and Fig.3. The 1st response would be presented through the avatar using the representation of the stereotypes (emotion and voice) mentioned above. Then the collected information for the patient user is also represented in the next cycle of diagnosis hierarchy, for another round of reasoning in the search engine. The information knowledge is represented as semantic net and based on the stereotype representation. The domain knowledge is specified by automatic retrieval in establishing a link between the ontology and the patient database.

The word selection is specified through the keywords. The schemata outline (as above) would construct the conceptual schema that would be used to do search in the semantic net based on the situational abstract articulated on the tow views, namely the mental and physical views.

The semantic net is constructed based on Object Web ontology (OWL). The data base is constructed such that the diagnosis would be articulated on structural hierarchy. For example pain, with fever, specify the diagnosis of pain fever class hierarchy, then pain would be specified as location by the user answer.

We establish a process of finding the reasoning of the system using these two types of ontology. Also this problem is called as ontology mapping (Kalfoglou,2003), to establish the semantical relation between procedures and entities among the mapped ontologies based on the previously explained stereotype views. We align the properties of physical diagnosis specified by the medical doctor with those related to cognitive reasoning based on the patient mental cloning articulation. Features expressed by stereotype Meta data definition mentioned above are used to make such alignment. The mapping is an abstraction that encapsulate the features (properties) related to certain abstraction in an ontology and reflect or map that feature into other ontology such that to qualify the related features through such mappings. This semantic level mapping based on conceptual schema related to each ontology. The mapping feature would provide coordination among different schema such that to establish semantic correspondence for reasoning purposes, in semantic web bases reasoning fashion. This would enhance and smooth the interoperability on service through different schema reflected on different type ontologies. As shown in Fig.2 and Fig.5., This mapping is incremental process as the

patient produce new schema and also the VDS consume this schema to produce another request by which the patient user would correspond to produce another schemata to be correspondingly, consumed again by the diagnostician (the system). This procedure is recalled based on mutual induction mapping discovery through conceptual schemata.
This is incremental indexing schema because the process is qualitative driven by the diagnostician. It represents incremental diagnostic refinement by including new collected purified information.

2.1 Implementation Aspects

Ontologies used in semantic web consist of hierarchical description of concepts and their properties in a domain (nest of concepts organized due to the nature of the situation instantiated from the integrated ontologies). Fig. 2 shows the details of the system implementation.

OWL (web ontology language), is knowledge representation scheme in semantic web exploiting web standards (XML, RDF). OWL is suitable to specify medical knowledge. We think OWL is more suitable for us than OBO as the later is mostly suitable for biological application, and its format does not include all the feature of OWL.

Deductive inference is used based on explicit given knowledge, represented by description logic, like RACER www.racer-systems.com/ We envisage using the OWL axioms and class constructors as descriptive logic for explicit inference from medical knowledge base.

For example, there is a correspondence relation between the medical process integration “drugs” and “medical decisions” domains. Consequently, there is semantics alignment integration among the instances semantic selection between, process decision and process of selecting the best match instances of drug property that fit to the decision to be expressed to the patient. (as shown in Fig.2).

We envisage templates that can be used by the diagnostician for matching diagnosis use cases to the drug prescription databases impeded in the knowledge base. This would be a sub ontology derived from the aligned two ontologies, (mental and physical). We envisage using a sequence diagram with association rules to examine interactions arising in various patient scenarios to establish the validity of diagnosis procedure as approved by the diagnostician.

Discovering association rules is an important data mining problem. For example patient who has running nose can be either allergenic side effect or a side effect of cold sickness. Therefore, the main purpose of implementing relationships in the knowledge base is by analyzing the data as reference during decision making.

Protégé UMLS plugin supports browsing and be use to query the UMLS knowledge base for medical keywords and retrieve them in terminological format. We construct domain ontologies by entering diagnosis related data and storing them in formats standards like OWL. The formal of OWL is provided by description logics (DLs). DLs are used to describe structured objects whose parts are interconnected in complex ways, such as medical diagnosis. OWL facilitates greater machine interpretability of Web style content than that supported by XML, RDF, and RDF Schema (RDF-S) by providing additional vocabulary along with a formal semantics. Instance data pertaining to the two view mapped ontology is making the assertion in terms of DL using Ontomat. OntoMat http://annotation.semanticweb.org/ontomat Public annotation tool is used to build OWL instances, and attribute relations, participate in the logical part of DL.

MD doctor diagnosis routines, as well as the MD personality (mental view) are added to the action scenario related to diagnosis (Fi.g.2). All these knowledge based are to be represented as a concept in DL in structural formal way using the stereotype based views mentioned above. The reasoning would be reflected through what we called as diagnosis map: reflects the clustering of different knowledge map articulated through the mapping of the two previously mentioned views (mental and physical) shown in Fig.5.

Also, there is a correspondence to the patient pattern: behavioural pattern that is reflected by the mental view ontology along with the attributed values of the physical view. Recall that the physical view is values reflecting by the physical status of the patient. This all resembled in profile processor shown in Fig.2. The strategy of changing diagnostician (i.e., MD) routines would be affected by specified instances of patient observation, these related observation would be categorized in a region that to be confirmed by actual MD, like blood or else physical collected data analysis. In most cases MD chose from limited evoked set of drugs which comes up in their minds, given a certain health problem of a patient. This evoked service is influenced by MD mental states, background and other local parameters. MD usually does not consider all possible treatment options, but chose approximately among two to 5 different options reflected to his/her experiences. This is resembled by the Emotion Estimate processor in Fig.2.

The knowledge base diagnoses scenarios can be revised and updated based on new diagnosis scenarios and participate to revise this efficiency related issue. However, it is still be approved by the MD in order to be used by the system. We currently are collecting these action scenarios from a hospital case study in Iwate region, in Japan. We would report on this in another paper.

3 CONCLUSIONS

This paper is reporting a progress status of our project related to mental cloning based concept on how to reason and represent human emotion in scientific way and use that emotion to reason with human user. We articulate such realization to establish a virtual medical doctor for diagnosis purpose. The MD is a real person that based on interviews, we extract her/his personality that is to be used into the system and act on his/her behalf on mental basis using her/his routine diagnosis procedure (knowledge and scenarios). Using this with other related information we created a system that interacts with the patient user based on Transaction analysis protocol. The system would be examined in Beta space at a hospital where that MD is working. We have represented the patient mental view and physical view. We have aligned and mapped these two views to discover the best integrated correspondence that resulted in a set of key words that would be used in searching the best action scenario relative to patient case. The discovery is incremental and cascade. The implementation outline of our system is presented in this paper. All diagnosis knowledge of MD is stored in the knowledge base as semantic net and in OWL. For testing purpose we have used UMLS for knowledge based, as it is based on semantic net. The mapping is based on DL. The system is under construction and to be installed in a hospital in Iwate region in Japan by 2010.

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REFERENCES

Annette ten Teije (ed). 2008 Computer-Based Medical Guidelines and Protocols: A Primer and Current Trends (Studies in Health Technology and Informatics, IOS press, ISBN**:** 978-1-58603-873-1

Fujita, H., Hakura, J, Kurematsu, M., 2009 "Intelligent human interface based on mental cloning-based software" *International Journal on Knowledge-Based Systems, Elsevier,* 22 (3), pp. 216-234, April.

Fujita, H., Hakura, J. Kurematsu, M. Chida, S. and Arakawa, Y.:2008 "Empirical based Techniques for Human Cognitive Interaction Analysis: Universal Template Design", *the 7th New Trends in Software Methodologies, tools and Techniques (Proceedings of SoMeT_08),* pp.257-277. IOS press, ISBN: 978-1-158603-916-5

Hakura, J., Kurematsu, M., Fujita, H., 2008 An Exploration toward Emotion Estimation from Facial Expressions for Systems with Quasi-Personality, *INTERNATIONAL JOURNAL of CIRCUITS, SYSTEMS and SIGNAL PROCESSING,* Vol. 1, No. 2, 137-144.

Hakura, J., Kurematsu, M., Fujita, H 2009 «Facial Expression Invariants for Estimating Mental States of Person» Frontiers in Artificial Intelligence and application series, Volume 199, *New Trends in Software Methodologies, tools and Techniques (SoMeT_09),*. IOS press, ISBN: 978-1-60750-049-0.

Kurematsu, M., Ohashi, M. Kinoshita,O. Hakura, J. And Fujita, H., 2009: "An Approach to implement Listeners Estimate Emotion in Speech" Frontiers in Artificial Intelligence and application series, Volume 199, *New Trends in Software Methodologies, tools and Techniques (SoMeT_09),*. IOS press, ISBN: 978-1-60750-049-0.

Leflar,2005: Leflar, R.B and F. Iwata, "Medical Error as Reportable Event, as Tort, as Crime: A Transpacific Comparison," Widener Law Review 189, no. 25 (2005)

Mikkola, 2003, Hospital Pricing reform in the public health care system- an empirical case study from Finland, International journal of Health Care Finance and Economics, 3 (4) 267-286.

NIPSSR, 2006; National Institute of Population and Social Security Research, "Population Statistics of Japan," 2006; Tokyo: NIPSSR.

Horowitz: 1988 Introduction to Psychodynamics. A New Synthesis: By Mardi J. Horowitz. *New York: Basic Books,* Inc.

Kalfoglou, Y., and Scholermmer, 2003 "Ontology Mapping: the state of the art," The knowledge Engineering review, 2003.

Tanaka, M., Noguchi, M 2000: Concept Retrieval of Medical Text using UMLS, Japan Journal of Medical Informatics, Vol.20, pp.934-935.

Smith, 2000, Reforming Markets in Health Care-An

Economic Perspective, Open University Press, Buckingham, 2000.]

Trautmann, R. L. & Erskine, R. G. 1981: Ego state analysis: A comparative view *Transactional Analysis Journal*, 11, 178-185.

Weizenbaum, J., 1966: "ELIZA - A Computer Program for the Study of Natural Language Communication Between Man and Machine", *Communications of the Association for Computing Machinery,* Vol.9, pp.36-45.