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Applying Artificial Neural Network to Deep Learning and Prescriptive Analysis in Telemedicine Systems using Microsoft Azure Machine Learning

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Abstract:
The study aims to establish a deep learning and predictive model in the semantic TCM telemedicine system using Artificial Neural Network Microsoft Azure Machine Learning. In Chinese Medicine diagnosis, four examination methods: Questioning/history taking, inspection, auscultation (listening) & olfaction (smelling), and palpation. Deep learning is an appropriate technique for the clinical decision support. The result is promising. Next step including studying the herb-herb interaction. And when a model has been validated, it is easy to publish this as a web service with an auto-documented REST API, to be consumed by apps, and in future we deploy as SaaS and Integrative Medicine Model and using the Microsoft Azure and NVidia the state-of-the-art GPU Visualization Infrastructure and GPU Compute Infrastructure.

Keywords: Deep Learning, Predictive Analysis, Traditional Chinese Medicine, Telemedicine.

1. Introduction:

The knowledge of Traditional Chinese Medicine (TCM) has been in existence for more than 4,000 years. TCM is practiced in various forms according to the constraints imposed by different geographical and environmental conditions. One of the earliest definitions of the notion of Telemedicine is given in the publication. The basic requirement is to make use of the Internet to deliver medical care to every corner of the world. In this light any web-based medical system, independent of its size, has at least some telemedicine capability. Telemedicine systems can be broadly divided into different types with respect to their functions and goals as follows:

a) Curative systems – medical practitioners use the system to achieve the diagnosis and treatment goals;
b) Consultative systems– through the system interface the user can obtain needed information, such as information about named patent drugs, and addresses/expertise of medical practitioners in the region/vicinity;
c) Medical information management systems in terms of data storage and retrieval (e.g. medical images);
d) Decision support systems– this happens in various forms, for example, the physician, who is using a telemedicine system (e.g. the PuraPharm's D/P (diagnosis/prescription) system in a mobile clinic [1] may import biometric reports to aid the diagnostic decision/ precision.

2. The Knowledge consultation

The aim is to let people including laymen and registered medical personnel consult and verify knowledge if necessary, from the knowledge base. Yet, a knowledge base can be general purpose and similar to a dictionary in this sense. Or, it can be there to help experts to clarify doubts due to multi-representations owing to disparate national or regional conceptions of a medical phenomenon. A typical example in the Western/allopathic medicine area is the UMLS (Unified Medical Language System [2]), which was developed by the USA National Library of Medicine to resolve the differences in Western/allopathic clinical terminology due to regional and or national disparities. The UMLS is ontology-based. Another ontology-based system is the disease and treatment ontology for Western Allopathic Medicine. By its nature the UMLS is not for frontline clinical application to allow computer-aided diagnosis and treatment in contrast to the Nong's TCM (Traditional Chinese Medicine) telemedicine mobile clinic (MC) system discussed later. The UMLS is consultative in nature. That is, it is not a clinical system but a consultation setup that people can interact with to sort out terminology problems. Therefore, its aim is to provide an interactive learning, reference, and bridging mechanism for knowledge gaps in a global sense. For example, in conventional/Western/allopathic medicine different countries may have different definitions for an observed phenomenon. In order to resolve the similarity and differences of various definitions, as well as language peculiarities on a global scale, meta-thesauri can serve as an effective means as shown by the ULMS (Unified Medical Language System [2]), developed by the US National Library of Medicine.

3. Major aspects of the Ontology Base TCM Telemedicine System

We focused on the scientific and engineering issues that underpin the building of a semantically based clinical TCM telemedicine systems successfully. It will address the following issues to a varying degree: a) the meaning of telemedicine b) the TCM ambit, c) usefulness of ontology in the building of computer-aided TCM systems, d) choice of the tool for modeling the ontology blueprint layout, d) TCM telemedicine infrastructure and mobile clinics, e) ontology myth and conceptualization, how telemedicine system building can be automated with quality assurance, and f) how a telemedicine prototype can be and deployed over the web.

This requires that we address the following aspects:

a) Ontology Modelling
b) Ontology Implementation tool
c) Internet capability
d) Cross-layer logical transitivity
e) Automatic system generation
f) Pervasive support
g) Ontology Evolution

3.1. Ontology Modelling

The design of the system begins with the ontology model blueprint layout followed by the consensus certification. The ontology includes the whole or part of the formalisms and knowledge in the relevant domain. In this sense, an ontology-based system is data/knowledge oriented. This model should be understandable both by TCM domain experts and system developers so as to facilitate evaluation and critiquing of the Ontology by the domain experts for correctness and completeness.

3.2. Ontology Implementation Tool

The tool is usually a high-level language, which can relate all the concepts in the ontology into a logical subsumption hierarchy. The ontology modelling blueprint is mainly for human understanding, and the embedded subsumption hierarchy should be translated meticulously into the corresponding semantic net for machine understanding/processing/execution. Therefore, it is necessary to choose a tool that has the support of ontology Model blueprint-to-semantic-net translation. It is better for the conversion process to be automatic [3]. In this light, the languages (or metadata models/systems) proposed by W3C (World Wide Web Consortium) [4,5], namely, XML (Extensible Mark-up Language), RDF (Resource Description Framework), and OWL (Web Ontology Language) are good choices, for they have widespread automatic translation support.

3.3. Internet capability

Telemedicine relies on the Internet to achieve different goals on the web. For example, the telemedicine system may send out miners to search the web for necessary information to support the system's ontology evolution – the concept of a living ontology [6, 7, 8]. This is well exemplified by the 2nd generation of the PuraPharm D/P (diagnosis/prescription) telemedicine system that supports the YOT mobile clinics in Hong Kong. These vehicle-based mobile clinics have been treating thousands of patients weekly in the past few years.

3.4. Cross-layer logical transitivity

A practical telemedicine system should have a 3-layer architecture. The bottom layer is the knowledge/database that embeds the subsumption hierarchy that represents the logical relationships among the physical data items/entities included in the consensus-certified ontology. This subsumption hierarchy is also realized in the middle layer as the semantic net for machine understanding and execution. The top layer is the query system that implements the ontology for user understanding and manipulation. The user enters a query or command via the system interface. This query is then translated by the middle layer into the form understood by the semantic net, which executes the command and fetches the information for the user as the response. The three layers are logically cloning of one another, and therefore they should have cross-layer semantic transitivity. With this transitivity any entity in any layer should have corresponding representations in the other two layers.

It is useful here to compare our proposed architecture for the TCM Curative and Decision Support System with the 3 Layer Architecture of the UMLS consultation system.
The UMLS is ontology-based and has three distinctive layers: i) the modularized query system (the modules are semantic groups) at the top level, ii) the middle logical semantic-net layer, which was constructed from the semantics embedded in the information of the bottom ontological layer, and iii) the bottom ontology is integrated by nature and normally has a subsumption hierarchy of various sub-ontologies of different origins].

There is, therefore, some similarity between the overall structure of the two systems even though one is used for Curative and Decision Support Purposes whilst this is used as a consultation system.

3.5. Automatic system generation

Cross-layer semantic transitivity can be achieved correctly by automatic system generation or customization (ASG/C). This approach is, in fact, a new software engineering paradigm, which requires the user to provide the ontology blueprint layout. With support of the master ontology, where the ontology specification is either a part or the whole of it, the ASG/C mechanism generates/customizes the final ontology-based system in one shot

3.6. Pervasive support

A telemedicine system needs the support of a wireless-based pervasive computing infrastructure (PCI), which maintains the smart spaces for the collaborating systems. In the PuraPharm mobile-clinics environment, the collaborating systems are the mobile clinics. The essence of the PCI support is better explained by using the successful PuraPharm's mobile-clinic (MC) based telemedicine D/P (diagnosis/prescription) system depicted. The PCI maintains the smart spaces, which is each occupied by a mobile clinic. The mobile clinic than communicates with the central system, as well as its peers, via the wireless means provided by the PCI. The MC operation is semi-autonomous because the physician can treat the patient at the spot, but the case history of the patient may have to be downloaded from the central computer that runs the fast network. The MC has to inform the central system of its updated local drug inventory. The central system also collects the necessary MC statistics on-line for proactive planning and action. If the MC physician needs help in the diagnostic process, the central system would solicit the relevant information from other friendly sites via the Internet.

3.7. Ontology Evolution Approach

Here we will utilize a text mining approach together with a controlled update of a wiki which is a duplicate of the current master ontology. The Data and text mining approach suggests changes to the ontology wiki image of the TCM ontology. The proposed changes to the ontology are then subject to consensus certification and only those changes that are approved by this consensus certification are then included into the master TCM ontology.

Overview of the Ontology-Based Automatic System Generation (ASG/C)

It is useful to provide an overview of the ontology-based automatic system generation here so that the reader can get a better appreciation of the approach. The 3-layer architecture of the TCM System sheds light on how a practical ontology-based system should be built because of the following arguments:

(a) If the bottom ontological layer is the "required" knowledge by consensus certification, then the system created for the specification provided by a semantic group (top layer) only needs to be supported by the relevant portion, which is part of the master ontology. The portion, in effect, is isolated as the "local" ontology for the target system as specified. This isolation process is basically customization.

(b) If the specification by a semantic group is logically correct, then the corresponding error-free target system can be customized in one shot by using an appropriate automatic mechanism such as the EOD-ISD (Enterprise Ontology Driven Information System Development) paradigm. The customization automation cuts the development costs and ensures customer satisfaction by its short development cycle.

(c) If the "total" ontological knowledge could be drawn as a network or DOM (document object model - a synonym of the W3C for semantic net) tree, the isolated "local" ontology for the target system should have its local parser to work on it. The parser finds the answer for the query at the syntactic semantic group level (or query level) by inference. It traces out the unique operation or semantic path in the DOM tree or semantic net in a suitable manner for the input parameter set. Machine processing in the ontological context is parsing.

From the literature, the only software engineering paradigm that can support the ASG/C process is the EOD-ISD (enterprise ontology-driven information system development). The core idea of this paradigm is to generate cognate system variants from the same TCM onto-core master automatically. For example, all the PuraPharm's D/P systems are customized from the proprietary master/enterprise TCM onto-core by applying the EOD-ISD paradigm. Similar to the UMLS a D/P system always has three layers: i) the bottom layer – the portion of the consensus-certified master ontology known as the local onto-core for the target system; ii) the middle parsing mechanism that works with the semantic subsumption hierarchy (i.e. semantic net) embedded in the local onto-core; and iii) the query system that enables the user to interact with the system.

Deep Learning and Predictive Analysis

In Chinese Medicine Diagnosis approach, the filter-based feature selection is adopted in the processing of the input attribute. Filter Based Feature Selection uses different statistical tests to determine a subset of features with the highest predictive power.

A trainable classifier is developed for the model. A machine learning approach called multiclass neural network provides options for customizing the structure and behavior of the neural network, either by using the parameters and options in the designer.

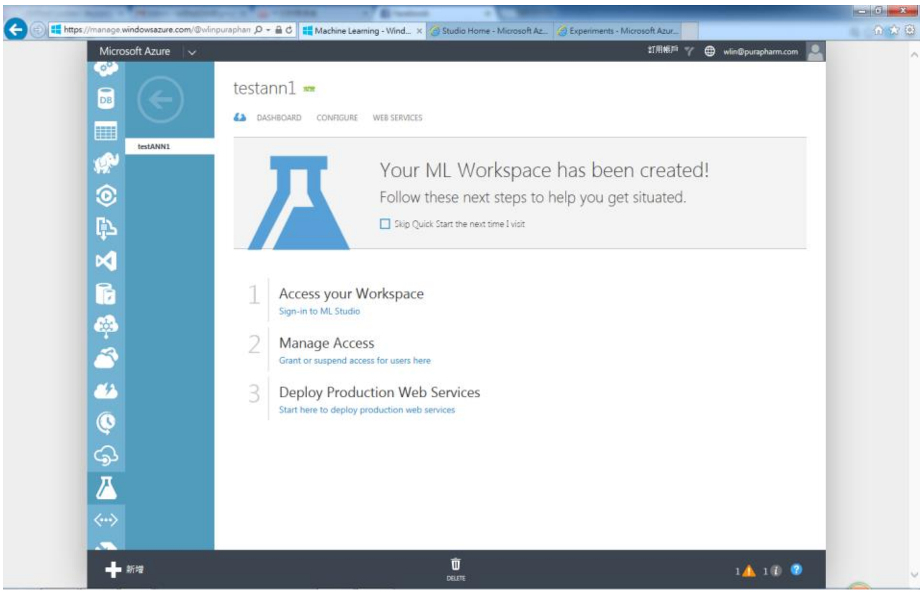

Fig. 1. The Microsoft Azure Machine Learning Studio

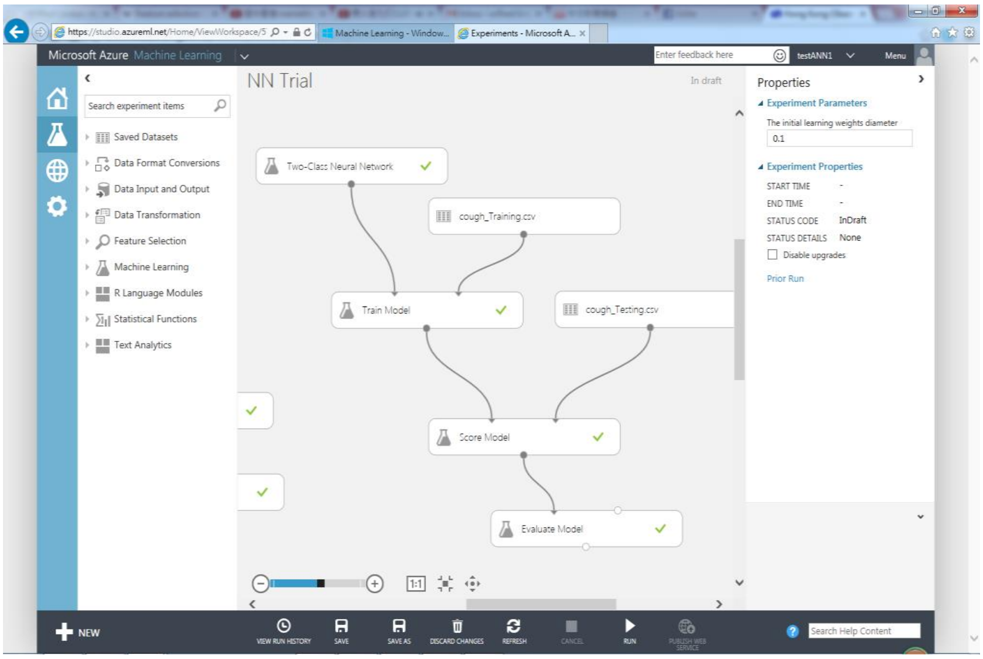

Fig. 2. The model is constructed in the Machine Learning Studio

A neural network can be as a weighted directed acyclic graph. The nodes of the graph are arranged in layers and are connected by weighted edges to nodes in the next layer.
In the case of a multiclass model, the number of nodes in the output layer should be equal to the number of classes. The remaining layers are called hidden layers. To compute the output of the network on a given input example, a value is calculated for each node in the hidden layers and in the output layer. Experiments using Microsoft Azure Machine Learning is conducted to evaluate the performance of the prototype.

The experimental results of cough is demonstrated in this paper. The training set is included 100 clinical cases. The reported symptoms are normalized in each row of the case. The training epoch is 1000 cycles. The results show that the positive correlation among the reported symptoms against the cough. The accuracy of the model is 77%.

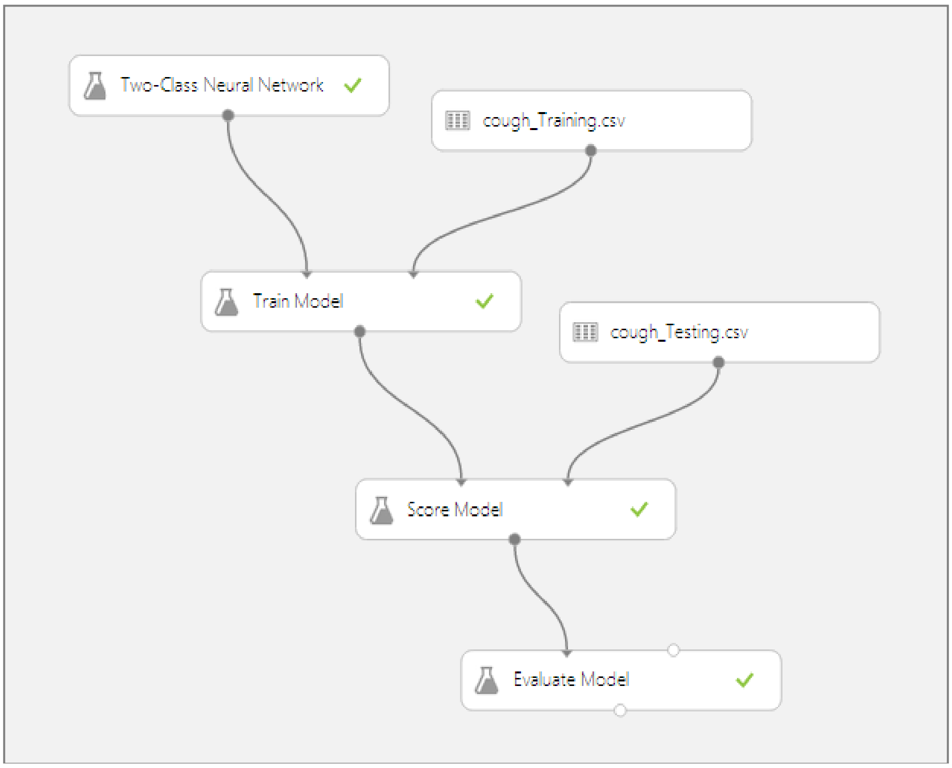

Fig. 3. The Deep Learning and Predictive Model

NN Trial › Score Model › Scored dataset

68667 rows   19 columns

	KeSou	ErBianChou	WeiEFengHan	YanTong	FaRe	MeiCha	YanGan	XiaoBianTiao	TouTong	KouGan	XianMai	HuaMai
Mean	0.3299	0.3094	0.1708	0.1409	0.0923	0.2347	0.0903	0.1138	0.1588	0.1177	0.7613	0.0864
Median	0	0	0	0	0	0	0	0	0	0	1	0
Min	0	0	0	0	0	0	0	0	0	0	0	0
Max	1	1	1	1	1	1	1	1	1	1	1	1
Standard Deviation	0.4702	0.4622	0.3763	0.348	0.2894	0.4238	0.2867	0.3176	0.3655	0.3223	0.4263	0.2809
Unique Values	2	2	2	2	2	2	2	2	2	2	2	2
Missing Values	0	0	0	0	0	0	0	0	0	0	0	0
Feature Type	Numeric	Numeric	Numeric	Numeric	Numeric	Numeric	Numeric	Numeric	Numeric	Numeric	Numeric	Numeric
	1	0	0	0	0	1	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	1	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	1	0	0	0	1	0	0
	0	0	0	0	0	0	0	0	0	0	0	0
	1	0	1	0	0	1	1	0	0	0	0	0

Fig. 4. The score model of the trained NN

KouGan	XianMai	HuaMai	ChenMai	TaiBo	TaiBai	SheHong	isKeSou	Scored Labels	Scored Probabilities
0.1177	0.7613	0.0864	0.0858	0.7808	0.8529	0.8271	0.0888	0.2608	0.2742
0	1	0	0	1	1	1	0	0	0
0	0	0	0	0	0	0	0	0	0
1	1	1	1	1	1	1	1	1	1
0.3223	0.4263	0.2809	0.28	0.4137	0.3542	0.3782	0.2845	0.4391	0.4209
2	2	2	2	2	2	2	2	2	4182
0	0	0	0	0	0	0	0	0	0
Numeric	Numeric	Numeric	Numeric	Numeric	Numeric	Numeric	Numeric Label	Numeric	Numeric
0	0	0	0	1	1	0	0	0	0.00352876
0	0	0	0	1	0	1	0	1	0.99812
0	0	0	0	1	1	0	0	0	3.10096e-11
0	0	0	0	1	1	1	0	0	1.16481e-7
1	0	0	0	1	0	1	0	0	0.0428049
0	0	0	0	1	1	1	0	0	0.000398793
0	0	0	0	1	0	1	0	0	0.0431649

Fig. 5. The score model of the trained NN

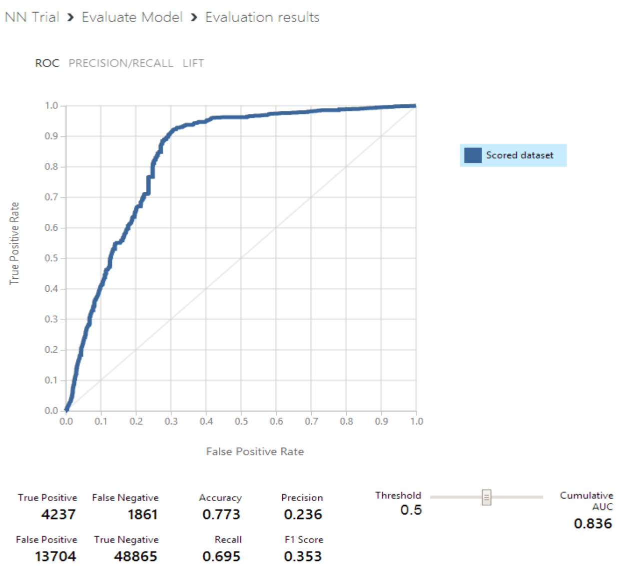

Fig. 6. The True Positive Rate vs the False Positive Rate

4. Conclusion

We propose to use deep learning and predictive analysis in Sematic TCM Telemedicine Systems using Microsoft Azure Machine Learning. The result is promising. Next step including studying the herb-herb interaction. And when a model has been validated, it is easy to publish this as a web service with an auto-documented REST API, to be consumed by apps, and in future we deploy as SaaS and Integrative Medicine Model [9, 10].

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