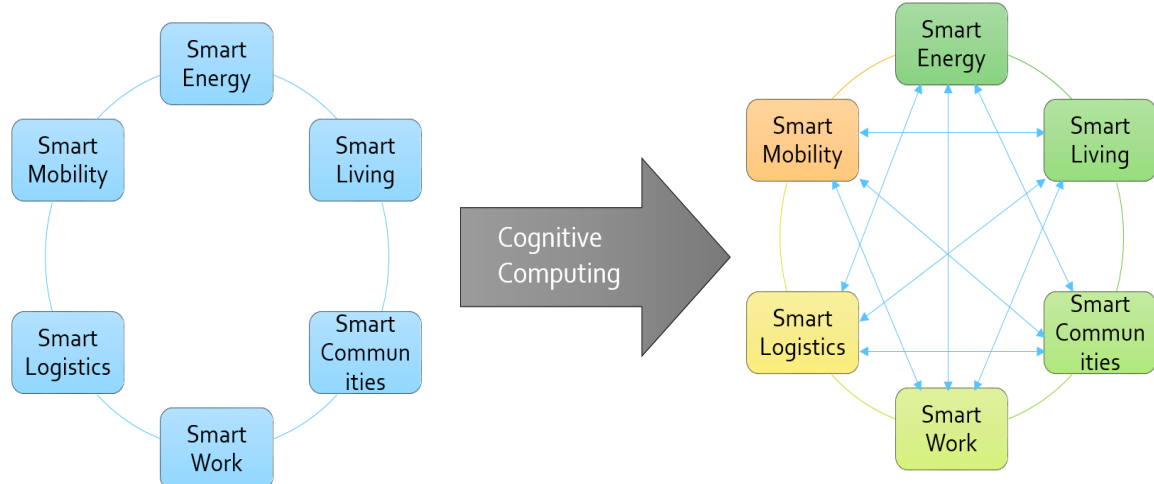# Application of Cognitive Computing : Smart cities towards Cognitive cities

Final Report
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Abstract

On the way to built cognitive cities from smart cities, I have applied different approaches of integrating data from existing mobile applications in current smart cities using knowledge graph and fuzzy cognitive maps and after analysing these methods with deep conception and calculations and considering the real time BigData ,these methods seems to be limiting in favourable outcomes as the complexity increases . In between, I got some solution of implementing the idea of meta application using fuzzy analytical hierarchy processing. Rather than gathering all the application data at one place, meta application access only instant useful data form existing applications and show the best alternative. I have explored this by considering transportation application.

Introduction

Building machines with intelligence has been a long dream of humanity. Although the journey has been tough and slow, the progress in machine intelligence and machine learning with optimizations of data analytic techniques and Big data offers the upcoming world of cognitive systems[1]. I have started my research with the word Cognitive computing and then particularly in its applications and the problem of converting cognitive cities from smart cities caught my eyes to go in deep study. After analysing the idea of creating cognitive cities which is all about integrating each and every possible applications available in smart cities and develop some application which is capable of assisting citizens of smart cities and serves like their personal assistance.

The population of cities is enormously increasing day by day and so the communication between cities and interactions between their citizens is taking more importance [2]. The independent digital systems within smart cities has enhanced city life as presented in [3]. Increase in the population of cities, the everyday life of their citizens has to be optimized and flexible. Existing applications has already enhanced the communication to a certain levels(e.g. Google Now) and QA application like IBM Watson[4,5]. Still a more easy accessible application that integrates all major domains is still not available which can be the effective step towards cognitive cities.

Related Work

There are lots of ongoing researches are going on as cognitive computing is a multidisciplinary paradigm of research , most of the scientists and researchers from vivid domains are continuously working on neuroscience technologies, data mining technologies and analytical methods, human brain concepts for better decision making process and perception using some predictive and descriptive analytics. Basically there are three major faculties of cognitive computer systems which are faculties of knowing, thinking and feeling[2].
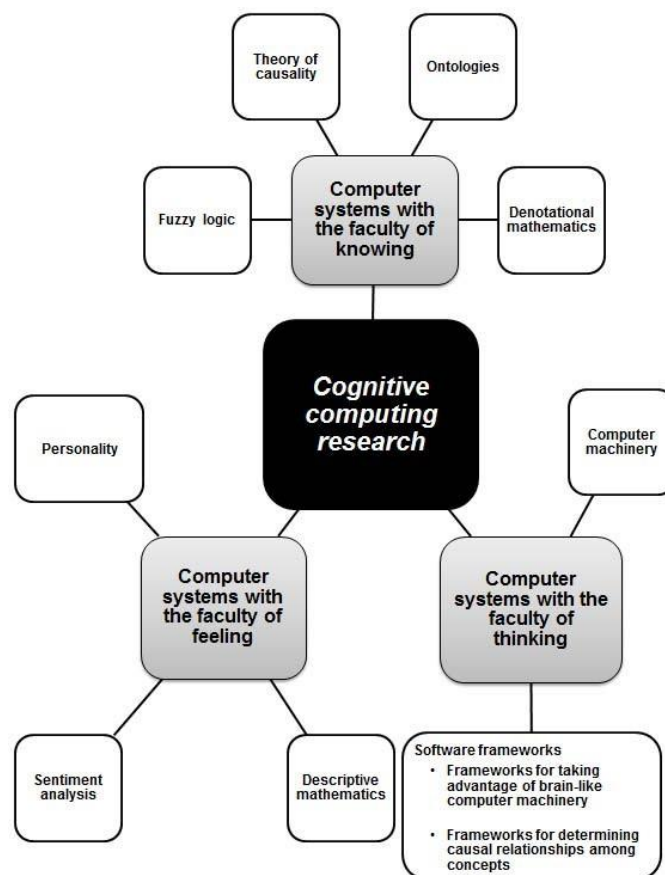

Fig. 1 : Research areas of Cognitive computing

Current Discoveries and applications of cognitive computing

Still there is a question of its real time use but after researching in deep about the use current discoveries based on cognitive concepts ,I found some glimpses of the use of the use of cognitive technologies. **Google's DeepMind** and Qualcomm's **Zeroth Platform**[4] are some of unique concepts implemented towards the cognitive era.

Google's DeepMind is developed to mimic some of actions of human brain using brain's short-term memory properties ,it saves the memories for the future use to perform some useful tasks on the bases of programming and algorithms. So this was the useful concept for business related decision making based on historical data. The another application of cognitive technology is Qualcomm's Zeroth Platform which is specially designed to integrate number of devices working together to identify different objects, images and also handwriting of a person to determine the relationship patterns of the whole environment[5].

IBM Watson the most impressive example of cognitive computing technology which is an advanced concept of Question-Answer(QA) based application. It gives functionality of asking questions and getting most of accurate answers as this application is developed using the natural language processing. So user ask question in their natural language commonly in English and Watson translate onto machine data to query the database and give right result within the factor of a second and there Watson has proved itself by defeating two of the greatest champions of all the time[5,6].

The latest advancement in the field of cognitive computing is prediction based mobile application platform "**Google Now**" developed by Google. It gives various suggestions to the user or we can also say that it serves user at the right place ,right information and at right time. It takes Google accounts activities from Gmail, Google Drive, Calender and based on that it predicts the instant activities that user needs to take care of[7].

Methods of knowledge representation

It is similarly critical to comprehend the take in the techniques to get the general idea of our usage of cognitive computing to the shrewd urban areas. We ought to know all the fundamental standards and speculations connected for our application. Here in this segment, two techniques for knowledge representation are mentioned and contrasted with have a certain justification.

1) Knowledge Graphs

There are several definitions of knowledge graph in various context. Sova[11] mentioned it as a knowledge representation through labelled nodes and links between them leads to structures that we call semantic networks, where in a knowledge graph is a specific kind of semantic network where we use few types of relations only[12]. The knowledge graph is deferent from semantic networks using the truth that types of relations are chosen explicitly.

Updating or adding new knowledge can be integrated easily.

Knowledge graph : Constructing of knowledge using three-steps[12]

**1.** Information extraction for text :

resulting in concepts of labelled points and the list of relations with types ,generating author graphs .

2. Concept identification :

determined and selected points are then used to design a graph from author graph and identify pairs of relative neighbours having similar concept.

3. Link and concept integration :

Now the step of more significance is to search an interesting patterns and forming extra connections using the existing links which matching the concept.
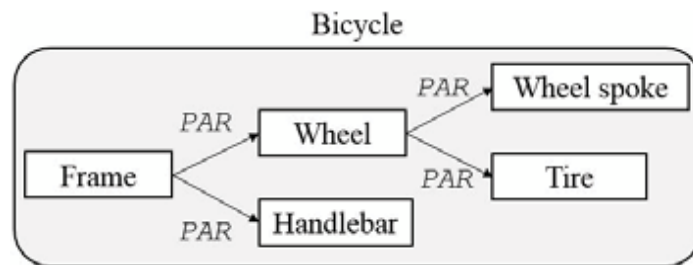
2) FCM

Fuzzy cognitive maps are the extension of cognitive maps. Simply, presenting signed weighted directed graphs also referred as digraphs are able to manage vagueness and partial truth as well as it is able to adapt human knowledge using fuzzy logic[13], however they are used in mostly soft computing still it provide powerful method for representing and evaluating various dynamic systems. FCM uses Matrices and adjacency matrices for defining relationships dynamically, sample example of FCM with adjacency matrix is shown in fig. 4.
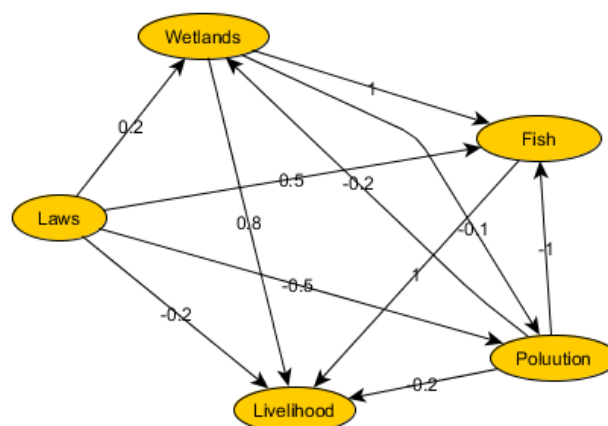
Fig. 4 : Sample FCM

FCM vs. Knowledge Graphs - A Comparison

In this comparison made here, the general factors of both the methods are compared which are presented in the previous section. Table-1 shows this comparison in very summarized manner.

Table-1: FCM vs. Knowledge graph Comparison[11,12,13]

|	**FCM**	**Knowledge Graph**
Input data	Tested actual information. Partial truth and uncertainty(fuzzy logic)	Tested actual information, true ,false are not allowed
Implicit knowledge	Statements and uncertain qualitative judgements	Knowledge not recognized by a computer but more relevant
Exclusive knowledge	No excluded knowledge	All other than tested knowledge is excluded
Items	Concepts(i.e. nodes) and links(edges)	Concepts(i.e. tokens) and relations(i.e. types)

Motivation of the idea of Meta application

In today's digitalized world of smart cities, people are using smart phones and they become used to it with most of its usage and functionalities. There are many plenty of smart applications are available specially in android and iPhone based mobile operating systems. So I thought something innovative in that direction and found such great idea of developing a mobile based automation application that takes care of each and every possible actions of a human. As most of the advanced technologies like Artificial Intelligence[8], cloud computing ,Big data and web technologies are developing very fast and so something that uses most of advanced technologies and generate strong decision making application which will able to decide user's actions following all the factors of user's environment. This is where the need/idea of meta application came into the picture.

Assumptions made while modelling meta application

- All the user of the meta application allow access to meta app to use data of most of the applications installed inside smart phone and user also agree to read/change most of the personal data like notes, appointment list in the calendar, contact numbers ,all the google accounts, social media accounts etc.

- Meta application constantly uses internet access so user should be connected with high frequency internet without losing access of it.

Architecture of Meta-Application
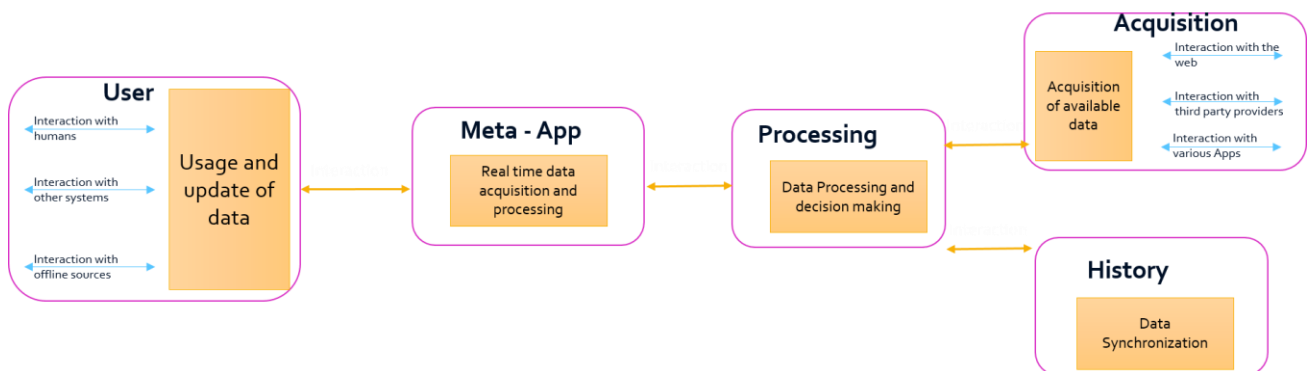
- Here is the basic architecture of the meta-application where there are four major building blocks communicating with each other for the decision making process[7].

  1) Data Acquisition

  2) History

  3) Meta App

  4) Processing

- These building blocks work individually but interact with each other and Fuzzy analytical hierarchy provides an interface to interact with each other.

- Dataflow activities are shown in the figure where data is flowing from either outside web/internet or from inside meta application.

(1) Data Acquisition

- Data acquisition and conditioning is greeted as the major activities among all the building blocks present inside the architecture.

- Global Data Repository is used as Database for the meta application architecture[9].Here, meta application uses Fuzzy Cognitive Maps(FCMs) to store all the data[15].

- Moreover, meta application provides Application Programing Interface(API) to transfer the data which also facilitates third party applications to improve the performance of Meta application.

(2) History

- By its name it is clear to understand that Meta application uses the previous activities of the user for similar actions. Consideration of these will enhance the decision making process for certain usual actions for the user.

- Meta application will store historical records and searches and synchronizing it constantly with the global data.

(3) Meta Application

- This is the only and most important building block inside the whole architecture as meta application serves and receive information from the user.

- It is Graphical User Interface considering user experience aspects so that user can have better understanding of the feature of the application.

- This will acquire data directly from user's mobile device which is sensing the surroundings and then it will transfer this information to the other building blocks of the architecture to process the data and after whole process of decision making it will show the final and the best alternative to the user.

(4) Processing

- This is the background tasks and programs executing to find out the best alternative for the user.

- To find out the best suitable approach, FAHP uses all possible information available from web as well as from history[14].

Limitations of Meta Application

- The major possible limitation is the protection of user's privacy as we have developed model assuming that user will give full access to his personal data through all existing application API. Meta app connects different heterogeneous systems for data access to derive most suitable alternative to the user [10]

- All the functionalities of the meta application depends upon the data received from existing applications and so some <u>limited or restricted access to the application data</u> would highly affect the functionality of meta application as meta app access all available application data through API and based on that only it calculates the best alternative for the user.

Drawbacks of Meta Application

- The conceivable <u>loss of self-responsibility</u> because of computerized reasoning is one drawback of the meta-application. Clients could indiscriminately take after the guidelines of the meta-application, in this way diminishing their own responsibilities to make proper decisions.

Evaluation of Meta application considering transportation example

To understand the actual use of meta application we can consider the transportation rout in the smart cities and following the schedules of user's appointments for attending the appointments on time with flexibility.

- For this, meta application will access the GPS sensor and colander application of users smartphone device and acquire the information about his/her current location and list of next due appointments.

- Meta application will continuously read data from the sensor based device and process the status so that if there is any changes among both of this ,then it will immediately suggests user the best alternative for that particular situation. Considering transportation, Meta application will calculate all the available resources and routs to reach the destination on time without any possible interruptions. To do this fuzzy logic will use all available information regarding this transport and it will also use the integrated transportation application through API. The table derived here shows the information retrieved from transportation application.

Time	Transportation Mean			
	Train	Bus	Taxi	Walk
Train	(1,1,1)	(2,3,4)	(1/7,1/6,1/5)	(5,6,7)
Bus	(1/4,1/3,1/2)	(1,1,1)	(1/8,1/7,1/6)	(4,5,6)

|				
Taxi	(5,6,7)	(6,7,8)	(1,1,1)	(7,8,9)
Walk	(1/7,1/6,1/5)	(1/6,1/5,1/4)	(1/9,1/8,1/7)	(1,1,1)

- The upper tables shows the FAHP Matrix and the meta app will constantly check the alternative as something unpredicted events like raining or some accidents in between the rout can results in delay which can prove the previous alternative wrong. In such case, newly generated priorities (e.g. from 0.2 to 0.4) will be checked again and if the output is 'OK' then it will show to the user's screen or the continuous checking for changes starts again. So this continuous checking of meta app will take care of such unexpected situations and show the right alternative again to the user. In the case that there is no such alternative to attend the scheduled appointment then there must be something implemented for handling such cases. After having lots of research into this the idea of automatically updating the appointment came into my mind and I have described it here using flow charts with this updating functionality of meta application.
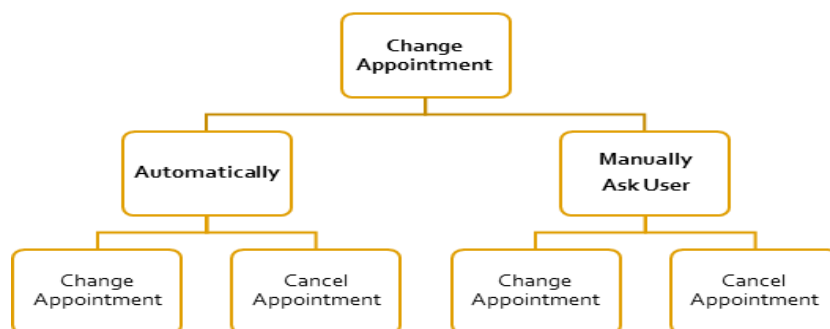
Figure (a) Flow Diagram of checking the possibility of the appointment
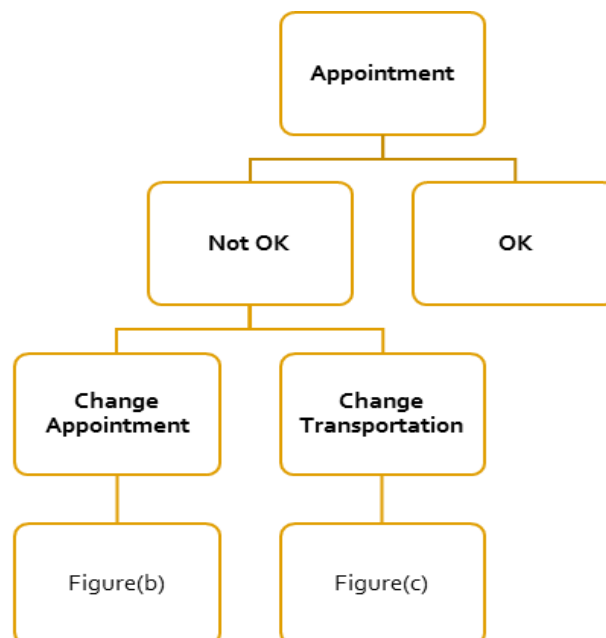
Figure(b) Flow diagram for checking transportations alternative
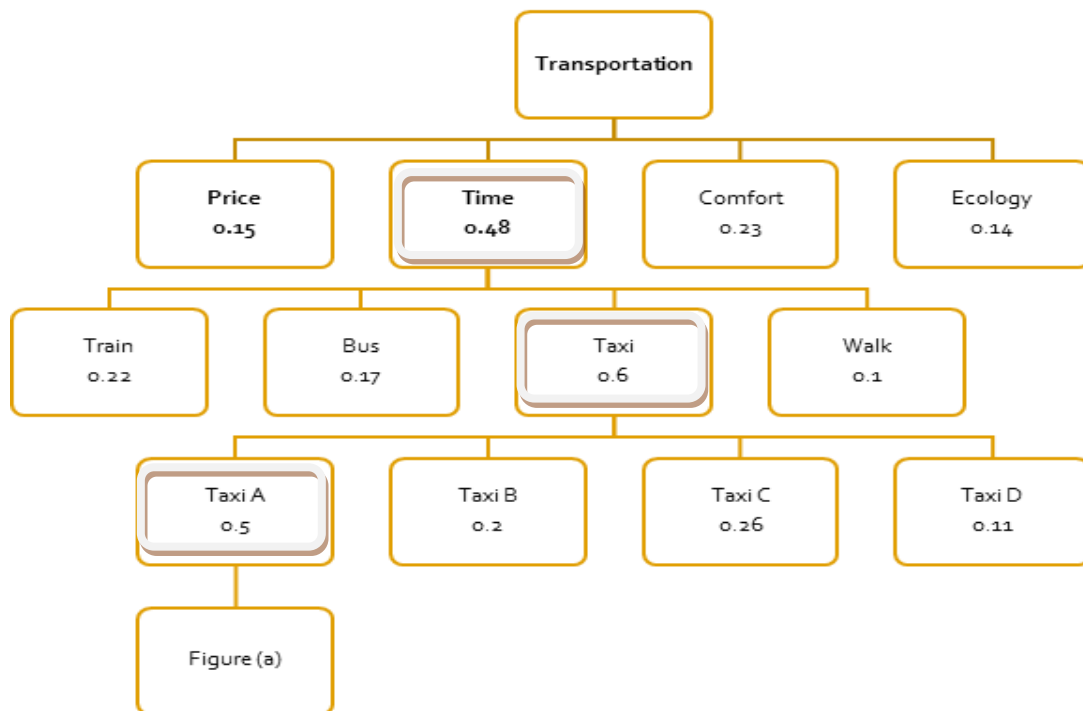
Figure(c) Flow diagram for making changes in appointments

- The figure shown here is checking the possibility of appointment to be held and if the output will be OK then it is the most suitable alternative for the user or else if its Not OK then it will again go for checking whether there is any other transportation alternative is available anf the flow will be continue from figure(c) else it will go for change of appointment and the flow will be continue from figure(b).

- When the control transfer to the figure(c), it will start checking for all available alternatives to reach the appointment destination on time and it will consider the priorities for selecting best suitable approach and it will go deep in that highest priority level. In our case Time has 0.48 which is highest among all other factors to be considered. So it will explore into that and again in the secong level Taxi has the highest priority for selection. So again go for all available taxis in that particular rout and here Taxi-A has the highest priority to be selected and so it will show return the final Taxi-A alternative to the user'sscreen.

- In the case that the the nearly due appointment can not be planned after checking all the alternatives then this flow will be executed. There can be two options that either meta app will reschedule the appoitment automatically as it has been given access the celander from the user at the time of installing the meta application or meta app will suggest the output to the user that this appoitment can not be possible for you and you can reshedule the appoitnment for next free time slots and it can also show available time slots for selection.

Conclusion and Future work

The innovative idea of developing meta application from prototype model described in this paper presents the basic usefulness of the selected FAHP approach and also the whole meta-application in point of interest. The exhibited meta-application upgrades multidirectional communication inside cognitive cities by integrating existing smartphone applications. Along with this, picking the accessible best in class functionalities and integrating them to enable all the automation functionalities. As a procedural background for the meta-application, FAHP empowers basic leadership taking into account existing fuzzy information, bringing about the most appropriate choices for its citizens. A restriction would be that the city, the application owners and the users all must be persuaded that information protection requirements are held fast to, as the meta-application can only achieve its full abilities with access to (open) information and data.

The challenging work to be continue with this research is to design the meta application by considering all the storage requirements and major application domains to be integrated with it. Moreover to enhance the approach of processing and storing useful information with respect to time and quality of outcome. A detailed study can be carried out to take all the requirements in detail and upgrading it with more and more integration of existing applications. An essential future research steps will be to understand the significance of the security issue and to do advance exploration to improve the privacy of citizens.

References

[1] Nahamoo, D. (2014). Cognitive computing journey. Paper presented at the Proceedings of the first workshop on Parallel programming for analytics applications, Orlando, Florida, USA.

[2] P. Kaltenrieder, E. Portmann, S. D'Onofrio, and M. Finger(2014), "Applying the Fuzzy Analytical Hierarchy Process in Cognitive Cities," Accepted for the 8th International Conference on Theory and Practice of Electronic Governance (ICEGOV).

[3] J. R. Boisson de Marca(2014), "Smarter Cities… and Wiser Ones?", In IEEE-The Institute 38(2).

[4] Gutierrez-Garcia, J. O., E, L., x00F, & pez, N. (2015, 12-16 July 2015). Cognitive Computing: A Brief Survey and Open Research Challenges. In Applied Computing and Information Technology/2nd International Conference on Computational Science and Intelligence (ACIT-CSI), 2015 3rd International Conference on (328-333).

[5] Delgado, R. (2015). Cognitive Computing: Solving the Big Data Problem?

[6] Banavar, G. S. (2015, 23-27 March 2015). Watson and the era of cognitive computing. In Pervasive Computing and Communications (PerCom), 2015 IEEE International Conference on (95-95).

[7] Kaltenrieder, P., Portmann, E., & Myrach, T. (2015, 2-5 Aug. 2015). Fuzzy knowledge representation in cognitive cities. In Fuzzy Systems (FUZZ-IEEE), 2015 IEEE International Conference on (1-8).

[8] M. Ito, K. Gutiérrez, S. Livingstone, B. Penuel, J. Rhodes, K. Salen ,and S.C. Watkins(2013) "Connected learning: An agenda for research and design," Digital Media and Learning Research Hub.

[9] E. Portmann and P. Kaltenrieder(June,2015), "The Web KnowARR Framework: Orchestrating computational intelligence with graph databases," in Information Granularity, Big Data, and Computational Intelligence, W. Pedrycz and S.M. Chen, Eds. Springer Verlag, Berlin Heidelberg(325-346).

[10] A. Martinez-Balleste, P.A. Pérez-Martínez, and A. Solanas(March,2013), "The pursuit of citizens' privacy: a privacy-aware smart city is possible," Communications Magazine, IEEE, 51(6),(136-141).

[11] J.F. Sowa(March,1987), Semantic Networks, in Encyclopedia of Artificial Intelligence, Shapiro, S.C., Ed. New York: Wiley(1011-1024).

[12] R. Popping(June,2003), "Knowledge graphs and network text analysis," Social Science Information, 42(1),(91-106).

[13] B. Kosko(July,1986), "Fuzzy cognitive maps," International Journal of Man-Machine Studies, 24(1),(65-75).

[14] S. Opricovic and G. H. Tzeng(2013). "Defuzzification within a multicriteria decision model," International Journal of Uncertainty, Fuzziness and Knowledge-Based Systems, (635-652).

[15] L. A Zadeh, "Fuzzy sets," in Information and Control 8(3), 1965, pp. 338-353.