International Journal of Multimedia and Ubiquitous Engineering
Vol. 4, No. 2, April, 2009

Trends in Ubiquitous Multimedia Computing

[1]Maria R. Lee, and [2]Tsung Teng Chen
[1]*Shih Chien University*, [2]*National Taipei University*
[1]*Maria.lee@mail.usc.edu.tw*, [2]*misttc@mail.ntpu.edu.tw*

Abstract

Ubiquitous multimedia computing becomes a major focus in scientific research due to recent flourishing of wireless communication infrastructures such as 3G, WiMax and RFID. There have been many surveys were written based on various ubiquitous multimedia computing related topics. If we can find a way to dash out the latest development in this particular science and technology field, it would be valuable to scientist and researchers. However, it is a challenging task to promptly and efficiently penetrate information for elevating scholastic research efficiency in large volume of information. The goal of this paper is to help us comprehend the scope and major themes of ubiquitous multimedia computing research. Different perspectives and methods were introduced to analyze leading research theme in particular in ubiquitous computing field is proposed. Factor analysis, pathfinder network and context-based ontology techniques are presented to display research directions by clustering scientific papers taken from the ISI web (CiteSeer papers). The results obtained show that recent popular research towards to pursue ubiquitous applications in particular in m-health. The beneficiary of the proposed methods could be for someone new to a specific domain in research study, who wishes to analyze and understand current development status of intended research study field.

1. Introduction

Ubiquitous multimedia computing becomes a major focus in scientific research due to recent flourishing of wireless communication infrastructures such as 3G, WiMax and RFID. There have been many surveys were written based on various ubiquitous multimedia computing related topics. It would be helpful if we are able to trace the latest development in this particular science and technology field.

However, scientific research papers are published voluminous amounts each year. It is a challenging task to swiftly and efficiently filter out information for elevating scholastic research efficiency in such large volume of information. It would be helpful to the researchers if there are knowledge visualization and acquisition techniques available to identify the evolution of specific science and technology space.

The goal of this paper is to help us comprehend the scope and major themes of ubiquitous multimedia computing research. This paper presents approaches to analyze trends of research themes. Factor analysis, pathfinder network (PFNeT), context-based ontology were used to acknowledge trends in the knowledge domain intellectual structure [8, 13]. The study draws on the literature published in the

citation data from ISI web in 2008, which is primarily located in the fields of ubiquitous multimedia computing.

Factor Analysis, PFNeT and context-based ontology are proposed, which are comparative to Author Co-cition Analysis (ACA) [5,6,7]. The intellectual structure of knowledge domain derived from a primary science and engineering oriented index is different from what has been provided by IS researchers [3,4,5,6,7], knowledge discovery and data mining systems [1,2,3].

The structure of the paper is the following. Three knowledge visualization techniques are introduced in this section to represent research papers with their inter-relationships in a knowledge domain. "Ubiquitous Multimedia Computing" is the primary knowledge domain for this study.

Section 2, 3, and 4 describe the contraction of research trends from the CiteSeer papers based on factor analysis, PFNeT and context-based ontology technologies. Section 5 analyses the results finding and the comparison among three knowledge visualization techniques. It is followed by the conclusions and future directions in section 4.

Table 1. Top 10 Research Trends in UMC field by factor analysis.

Factor	Descriptive Name	Variance Explained
1	Foundational studies of ubiquitous computing	17.123
2	Power aware routing protocol for wireless sensor network	3.047
3	Medical informatics, application of ubiquitous computing in health care	6.917
4	Context-aware workflow language based on Web services	5.105
5	Context aware computing	4.878
6	Ambient intelligent systems	4.854
7	Open services gateway initiative (OSGi)	4.766
8	Ubiquitous applications in education	4.350
9	Information technology as the competitive advantage of business	3.573
10	Tangible and graspable user interfaces	2.903

2. Factor Analysis

Factor analysis is applied as a data reduction or structure detection method [20]. The usefulness of Factor analysis technique is to reduce the number of variables and to detect structure in the relationships between variables. A co-citation matrix is derived from the citation graph to factor analysis.

The proposed procedure leverages the CiteSeer citation index by using key phases to query the index and retrieve all matching documents from it. The citation graph is

constructed by connecting all retrieved articles, which includes documents other than the schemes reviewed earlier. The resulted citation graph was built from the literature and citation information retrieved by querying the term “ubiquitous computing” from CiteSeer.

Instead of searching all papers in the citation index database, we limited our search to literature published in the citation data from ISI web in 2008. The initial citation graph contains 15,708 document nodes and 17,292 citation arcs; we pruned out papers were cited less than 3 times and the fine-tuned citation graph was built from 1,506 papers. Top ten research trends were identified by employing the factor analysis as listed in table 1.

3. Pathfinder Network

The Pearson correlation coefficients between items (papers) were calculated and used as the basis for PFNeT scaling [21, 22, 23]. The value of Pearson correlation coefficient falls between the range -1 and 1. The coefficient approaches to one when two items correlate completely. Items that closely relate, i.e., are highly correlated, and should be placed closely together spatially.

The nodes located close to the center of a PFNeT graph represents papers contributed to a fundamental concept, which are frequently referred by other peripheral literature that are positioned in outer branches. The distance between items is inversely propositional to the correlation coefficient, which maps less correlated items apart and highly correlated items spatially adjacent [8, 13].

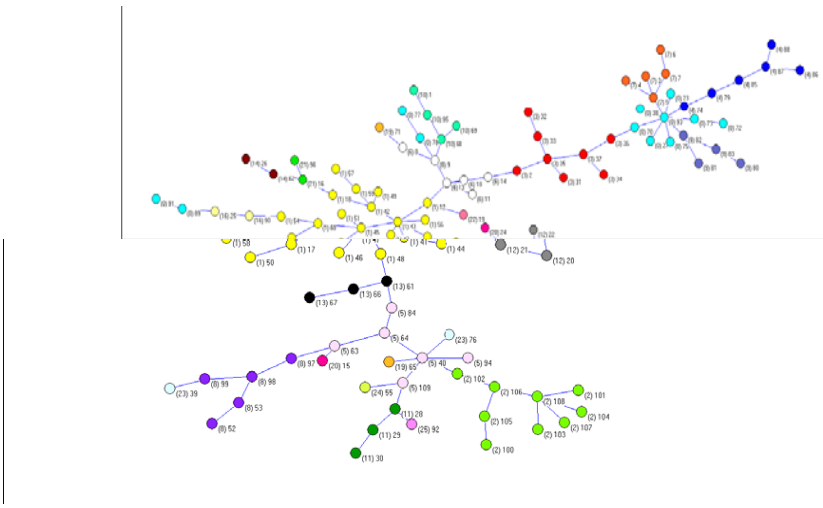

Figure 1. PFNeT Scaling of ubiquitous computing

The top ranked component cluster number 1, 5, 6 located close to the center of the PFNeT graph suggesting papers in these components play fundamental roles in ubiquitous computing research. Medical informatics, context-aware computing and

foundational studies of ubiquitous computing are important fields to ubiquitous computing research.

Figure 2 shows the relationship between the main components, which is derived from figure 1 by computing nodes in the same factor into a block to highlight the relationships between these themes. The double-arrowed lines in figre 2 indicate a connection relationship. Context aware computing (6 connections), foundational studies of ubiquitous computing (5 connections) and the topic-less one (4 connections) are the top three most connected components listed in decreasing connection counts [28].

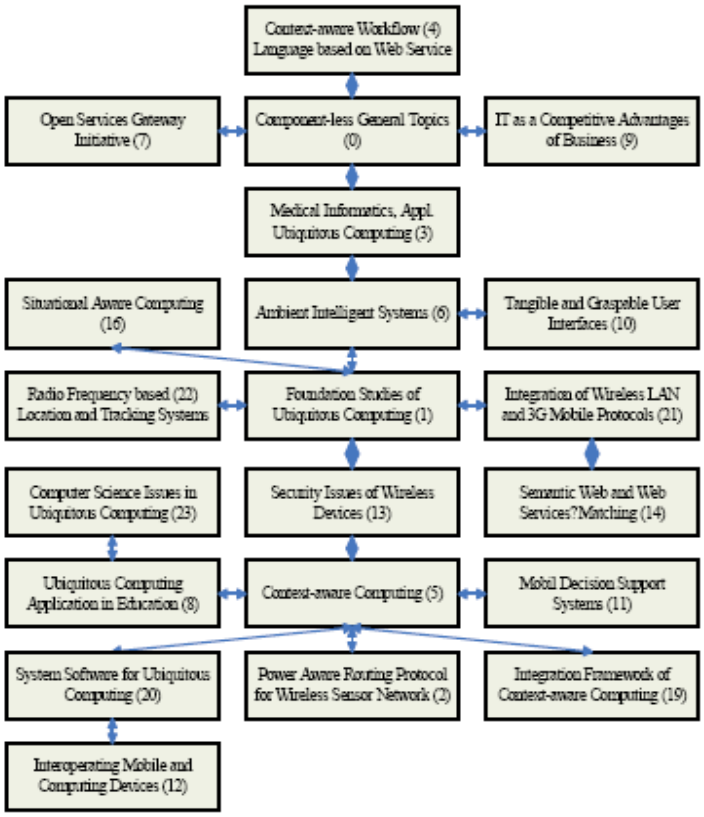

Figure 2. The relationships between the main components.

4. Context-based Ontology

Figure 3 illustrates a context-based trend generated on the basis of the amalgamation of ontology model and concept database. Based on the citation graph drew from factor analysis and PFNet, total of 209 papers were used to derive the ontology model and the concept database. The concept database is constructed from the "ubiquitous multimedia computing" concepts.

Ontology provides structure, organization, guidance and semantics for representation [10, 11, 12, 19]. We can classify the existing context models to three categories: application-oriented approach [1], model-oriented approach [18] and ontology-oriented approach [27]. However, the existing context ontologies lack of

generality. We present our context-based model to address the generality however, it is less formal.

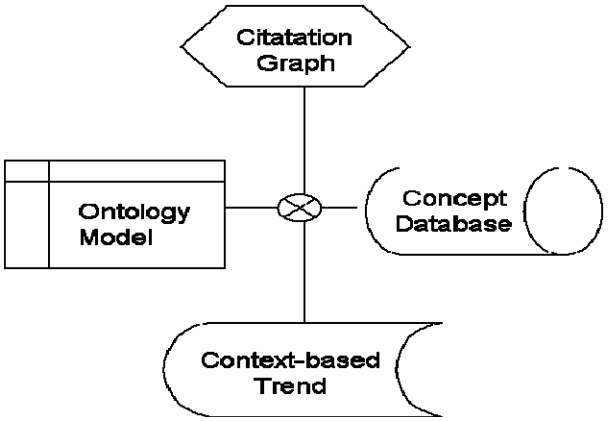

Figure 3. The construction of context-based trend.

The concept database includes various ubiquitous multimedia computing related concepts. These are ubiquitous multimedia services and applications, intelligent context-awareness for UMC, pervasive and interactive multimedia systems, UMS for human communication interaction, multimedia systems, architecture and applications for UMC and multimedia networking or UMC, P2P multimedia systems and streaming for UMC, multimedia file systems, databases and retrieval for UMC, mobile multimedia systems and services for UMC, multimedia modeling and processing, emerging standards and technologies for UMC, ubiquitous multimedia business model, etc.

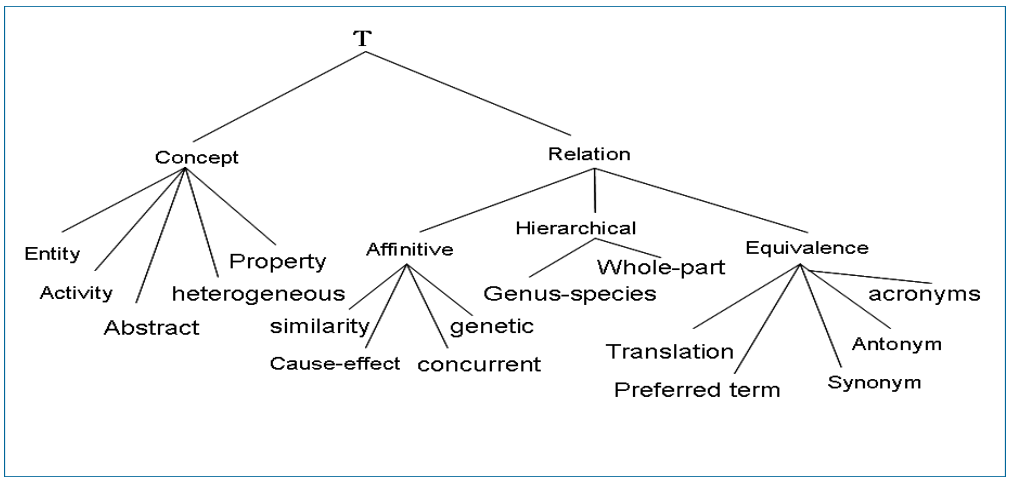

Figure 4. A Proposed Ontology Conceptual Model.

The context-based trend approach represents a grouping of concepts based on "ubiquitous multimedia computing" context. It was drawn from the ontology model

and the concept database. Table 2 shows top 10 context-based trends in ubiquitous multimedia computing research field.

Figure 4 shows a proposed ontology model with concepts and relations. The root symbol T is a neutral representation for the universal entity. T is divided into the classes of *Concept* and *Relation* [13, 14, 15, 16, 17]. The model supports affinitive, hierarchical, and equivalent relationships among concepts. Inheritance is shown by the hierarchical graph, which illustrates each class on the lower level inherits properties from the preceding level. The concept includes entities, activities, abstracts, properties and homogeneous classifications.

Table 2. Top 10 context-based trends in UMC field.

No.	Context-based Trend	Total Number of Papers
1	m-Health	61
2	Ubiquitous multimedia services	28
3	Context-awareness for UMC	18
4	Multimedia database for UMC	15
5	Mobile Internet Applications	7
6	Modeling and processing for UMC	7
7	Location-based services	7
8	Pervasive, interactive and P2P systems	6
9	Security issue on UMC	6
10	User interface in UMC	5

The number one context-based trends in UMC filed is m-health, which include health information systems, clinical bioinformatics, ubiquitous computing in health care, clinical decision support, patient access medical records, smart house for older persons, emergency telemedicine system, computerized patient record, network-home-care management system, home telemonitoring, telecardiology applications, electrocardiographic recording, wearable systems for health care applications, etc.

Ubiquitous multimedia services, as the number two from the list focuses on ubiquitous information services, mobile-stationary in transport industry, nomadic support, accelerometry, disaster management, engineering information service, etc.

The third from the list is context-awareness, which include context-awareness applications, context-aware computing technology in intelligent decision-making, context-aware product bundling architecture, context-aware comparative shopping, context management services, context-aware adaptive information system, context-aware proactive service, context-aware migratory service, etc.

The following paragraphs delineated the context-based trends from the 4^{th} to the 10^{th} elements in Table 2.

Multimedia database for UMC includes data management framework for ubiquitous computing environment, contextual retrieval, data management in smart vehicle space,

data integration and analysis, service discovery, querying and interaction in ubiquitous computing, ontology-based query processing, content-based image retrieval, etc.

Mobile internet applications include adaptive hypermedia, adaptive web, web messaging, a GSM and internet services-based system, internet-based store-and-forward video home telehealth system, ubiquitous web services, etc.

Modeling and processing in UMC includes multi-agent-based modeling simulation, and computational assistance in a ubiquitous environment, consistent modeling of users, devices and sensors in UMC, knowledge descriptive model, distributed system service modeling.

Location-based services include location awareness through trajectory prediction, cashe management in location-based services, adaptive on-device location recognition, location-aware resource management, and location-aware applications with an infrastructure visualization layer.

Pervasive and interactive systems include pervasive sharing in ubiquitous system, automated spoken dialogue system for hypertensive patient home management, peer-to-peer presence information system, etc.

Security issues on UMC consist of situation-aware security in autonomic computing, elastic security Qos provisioning, smart identification frameworks, RFID security system, and information security management system in ubiquitous computing.

User interface in UMC includes users' preferences for ubiquitous computing applications at home, developing indoor and outdoor user interfaces to a mobile augmented reality system, distributed user interfaces for clinical ubiquitous computing applications, etc.

5. Discussions

Based on the ubiquitous computing research trends derived from factor analysis, PFNeT and context-based ontology from published papers in ISI web in 2008, we have noticed that the application of ubiquitous computing in health care is recent popular research trends in UMC field. Context-awareness for UMC is also an interesting research topic. Abowd and Mynatt [26] investigated ubiquitous computing publications in 2001, natural interface, context-aware applications and automated capture and access were main research focuses.

Power aware routing protocol for wireless sensor work appears to be one of the important researches based on factor analysis and PFNeT, but not in context-based ontology. The power saving algorithms and protocols are the focus of many ubiquitous computing researches. Multimedia database is a major trend in context-based ontology but not shown in factor analysis and PFNet. One of the explanations could be the factor analysis and PFNeT extract concepts from "ubiquitous computing" whereas the context-based ontology focuses on "ubiquitous multimedia computing". The factor analysis and PFNet provide a broader view of the ubiquitous computing study whereas the context-based ontology focuses on ubiquitous multimedia computing context.

Table 3 shows the comparison among proposed three knowledge visualization techniques. Factor analysis and PFNet are better used in addressing the scalability, speed and automated technology. The result obtained from the ontology model and concept database is context-related because the grouping of context concepts capability.

The result differences among the three models are:

- factor analysis provides popular topics,
- Pathfinder Network provides important/essential topics, but not necessary popular topic
- Ontology provides important topics in context-dependent base.

Table 3. Knowledge visualization technologies comparison.

	Factor Analysis	PathFinder Network	Ontology
Process	Auto	Auto	Semi-Auto
Scale	Large	Large	Small-medium
Speed	Fast	Fast	medium
Result Obtained	Concept-based	Concept-based	Context-based

6. Conclusions

Three knowledge visualization techniques have been presented in this paper, and they are factor analysis, pathfinder networks and context-based ontology. Literature published in the citation data from ISI web in 2008 were used to drive the research trends. The comparison among the three techniques has also been discussed. The results obtained show that application of ubiquitous computing in health care is one of the most popular research area, followed by context awareness computing. The results obtained also show that the factor analysis and PFNet provide a broader view of the "ubiquitous computing" study whereas the context-based ontology focuses on "ubiquitous multimedia computing" concepts.

The beneficiary of the results obtained could be for someone new to a specific domain in research study. The proposed techniques could also be re-used in a number of ways and could possibly be shared across different research domains. One of the future research directions is to apply the proposed approaches to other disciplines. In addition, the techniques can potentially be leveraged to research theme networks, linking the relationships between publications, citations, research projects and even patents. We also would like to apply the proposed approaches by using different database, for example, google scholar.

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Authors

Dr. Maria R. Lee (maria.lee@mail.usc.edu.tw) is an associate professor in the Department of Information Technology and Management and Dean of Research and Development Office at the Shih Chien University, Taiwan.
She earned her Ph.D. in Computer Science degree from the University of New South Wales, Australia. Her current research interests include: knowledge management, Web 2.0 and wireless applications.

Dr. Tsung Teng Chen (timchen.ntpu@msa.hinet.net) is an associate professor in the Graduate Institute of Information Management at the National Taipei University, Taiwan. He earned his Ph.D. degree majored in Management Information Systems from University of Arizona. His current research interest include information science and information visualization.