Lecture Notes in Networks and Systems 585

José Manuel Machado · Pablo Chamoso · Guillermo Hernández · Grzegorz Bocewicz · Roussanka Loukanova · Esteban Jove · Angel Martin del Rey · Michela Ricca *Editors*

Distributed Computing and Artificial Intelligence, Special Sessions, 19th International Conference

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Volume 585

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Preface

Research on Intelligent Distributed Systems has matured during the last decade, and many effective applications are deployed now. Nowadays, technologies such as Internet of Things (IoT), Industrial Internet of Things (IIoT), Big Data, Blockchain, and distributed computing, in general, are changing constantly as a result of the large research and technical effort being undertaken in both universities and businesses. Most computing systems from personal laptops to edge/fog/cloud computing systems are available for parallel and distributed computing. Distributed computing performs an increasingly important role in modern signal/data processing, information fusion, and electronics engineering (e.g., electronic commerce, mobile communications, and wireless devices). Particularly, applying artificial intelligence in distributed environments is becoming an element of high added value and economic potential.

The 19th International Symposium on Distributed Computing and Artificial Intelligence 2022 (DCAI 2022) is a major forum for presentation of development and applications of innovative techniques in closely related areas. The exchange of ideas between scientists and technicians from both academic and business areas is essential to facilitate the development of systems that meet the demands of today's society. The technology transfer in this field is still a challenge, and for that reason, this type of contributions is specially considered in this symposium. DCAI 2022 brings in discussions and publications on development of innovative techniques to complex problems. This year's technical program presents both high quality and diversity, with contributions in well-established and evolving areas of research. Specifically, 46 papers were submitted, by authors from 28 different countries (Angola, Argentina, Bahrain, Bangladesh, Brazil, Bulgaria, Burkina Faso, Canada, Chile, Colombia, Denmark, Ecuador, Finland, France, Germany, India, Italy, Japan, Lebanon, Nigeria, Poland, Portugal, Qatar, Russia, Spain, Turkey, UK, USA), representing a truly "wide area network" of research activity. Moreover, DCAI 2022 Special Sessions have been a very useful tool in order to complement the regular program with new or emerging topics of particular interest to the participating community. The technical program of the Special Sessions of DCAI 2022 has selected 22 papers (12 full papers). As in past editions of DCAI, there will be special issues in highly ranked journals such as Electronics, Systems Journal, International Journal of Interactive Multimedia and

Artificial Intelligence, Smart Cities Journal and Advances in Distributed Computing and Artificial Intelligence Journal. These special issues will cover extended versions of the most highly regarded works, including from the Special Sessions of DCAI, which emphasize specialized, multi-disciplinary and transversal aspects. This year, DCAI 2022 has especially encouraged and welcomed contributions on: AI-driven methods for Multimodal Networks and Processes Modeling (AIMPM), Computational Linguistics, Information, Reasoning, and AI 2022 (CLIRAI), Intelligent Systems Applications (ISA), Mathematical Techniques in Artificial Intelligence and Machine Learning (MaTe-AI&ML), and New Perspectives and Solutions in Cultural Heritage (TECTONIC). Moreover, Doctoral Consortium Session tries to provide a framework as part of which students can present their ongoing research work and meet other students and researchers and obtain feedback on lines of research for the future.

We would like to thank all the contributing authors, the members of the Program Committee, the sponsors (IBM, Indra, Dipartimento di Ingegneria e Scienze dell'Informazione e Matematica dell'Università degli Studi dell'Aquila, Armundia Group, Whitehall Reply, T.C. Technologies And Comunication S.R.L., LCL Industria Grafica, AIR Institute, AEPIA, APPIA), and the Organizing Committee of the Universities of L'Aquila and Salamanca for their hard and highly valuable work. We are especially grateful for the funding supporting by project "XAI—XAI—Sistemas Inteligentes Auto Explicativos creados con Módulos de Mezcla de Expertos", ID SA082P20, financed by Junta Castilla y León, Consejería de Educación, and FEDER funds. And finally, we are grateful and value Program Committee members for their hard work, which has been essential for the success of DCAI 2022.

July 2022

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The original version of the book was revised: The affiliation of the editor Roussanka Loukanova has been updated. The correction to the book is available at
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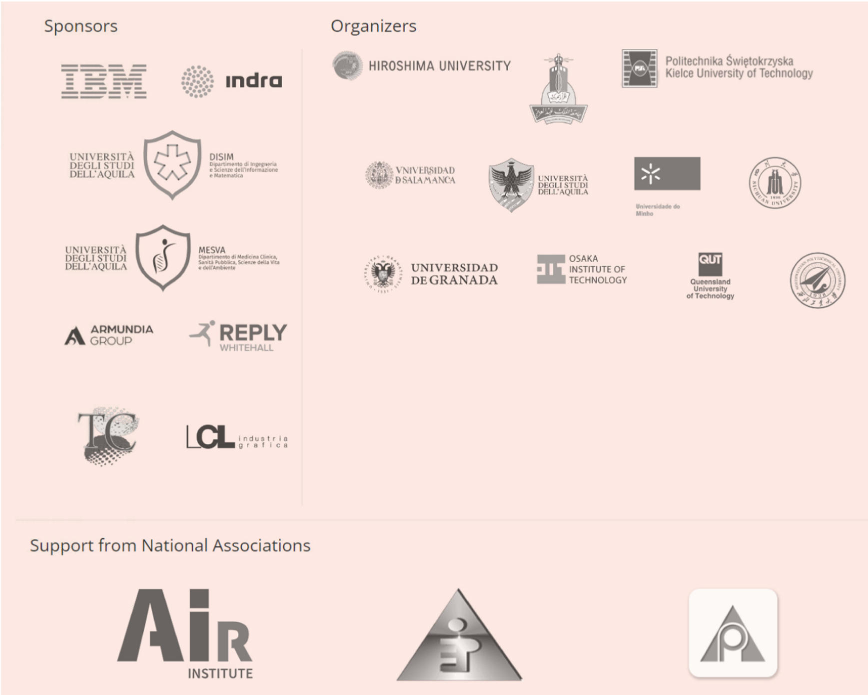

Contents

Special Session on AI-driven Methods for Multimodal Networks and Processes Modeling (AIMPM'22)

The special session entitled AI-driven methods for Multimodal Networks and Processes Modeling (AIMPM 2022) is a forum that will share ideas, projects, researches results, models, experiences, applications, etc., associated with artificial intelligence solutions for different multimodal networks born problems (arising in transportation, telecommunication, manufacturing, and other kinds of logistic systems). The session held in L'Aquila (Italy) as the part of the 19th International Symposium Distributed Computing and Artificial Intelligence 2022.

Recently, a number of researchers involved in research on analysis and synthesis of multimodal networks devote their efforts to modeling different, real-life systems. The generic approaches based on the AI methods, highly developed in recent years, allow to integrate and synchronize different modes from different areas concerning: the transportation processes synchronization with concurrent manufacturing and cash ones or traffic flow congestion management in wireless mesh and ad hoc networks as well as an integration of different transportations networks (buses, rails, subway) with logistic processes of different character and nature (e.g., describing the overcrowded streams of people attending the mass sport and/or music performance events in the context of available holiday or daily traffic services routine). Due to the abovementioned reasons, the aim of the workshop is to provide a platform for discussion about the new solutions (regarding models, methods, knowledge representations, etc.) that might be applied in that domain. There is a number of emerging issues with big potential for methods of artificial intelligence (evolutionary algorithms, artificial neural networks, constraint programming, constraint logic programming, data-driven programming, answer set programming, hybrid methods—AI/OR-Operation Research, fuzzy sets) like multimodal processes management, modeling and planning production flow, production planning and scheduling, stochastic models in planning and controlling, simulation of discrete manufacturing system, supply chain management, mesh-like data network control, multimodal social networks, intelligent transport and passenger and vehicle routing, security of multimodal systems, network knowledge modeling, intelligent web mining and applications, business multimodal processes, and projects planning.

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Multimodal Network Based Graphs of Primitives Storage Concept for Web Mining CBIR

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Abstract. Nowadays multimedia databases are becoming more and more popular. Because there are many images uploaded to the Internet there is a need of efficient querying and storing them. Additionally, a method of efficient web mining method also should be researched. The proper querying and storing data in a multimedia database is very crucial. In this paper a new concept of using Multimodal Network for storing and organizing graph of primitives for web mining Content Based Image Retrieval has been proposed. The graphs of primitives has been developed in our previous works in order to provide a new CBIR method. The usage of Multimodal Network would be beneficial for storing different types of nodes (e.g. nodes used only for organizing the hierarchy, nodes storing graph of primitives of objects or nodes storing image files). Additionally, the paper describes also modified K-Mean clustering method for gathering together in clusters similar graphs of primitives. Because of limited time, only preliminary experiments has been performed.

Keywords: Query by approximate shapes · Multimodal networks · Content based image retrieval

1 Introduction

Nowadays multimedia databases are becoming more and more popular. Because there are many images uploaded to the Internet there is a need of efficient querying and storing them. Additionally, a method of efficient web mining method also should be researched [4].

The proper querying and storing data in a multimedia database is very crucial, thus in our previous works we prepared some initial researches for the Content Based Image Retrieval algorithm in [5], crawling and retrieving images in [3] and the graphs of primitives used for objects description (which are defined as a modified graph with additional properties [5]) comparisons in [4].

Through the years researchers developed many graph storage approaches. There are methods which uses relational databases with SQL [13,16] and NoSQL

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approaches [1,6]. Graphs may be also stored using hierarchic structure, for example [12]. An example approach which is dedicated to distributed graph storage systems was described in [20]. Moreover there are some transactional approaches, for example [21] and dedicated fault tolerancy and scalability [11]. For more efficient storage there are also used approaches like for example reinforcement learning [19] or graph neural network [18]. Another approach may be using Multimodal Network in order to organize different graphs.

Multimodal Networks have become more and more popular in researches in recent years. They are designed on a basis of graphs an hypergraphs in order to add capabilities for representing relationships which are present in biological networks or databases [7]. The definition of a Multimodal Network extends the classical graph 2-tuple (Vertices and Edges) to 3-tuple (Vertices, Modal hyperedges and Modes) [7]. A modal hyperedge is an edge which has a specified type and a type is defined by a mode [8]. This specific type of relationship may be very useful in designing organization of a database of graph of primitives, which will be described in more details in next sections. Multimodal Networks and their variations are mainly used in biology [7], transport [9], vehicle routing problems [15,17], supply chains [14] and batch production flows [2].

The main motivation for this paper is to prepare initial concept for the graphs of primitives storage in Multimodal Network which is able to represent different relations between nodes used for organizing graphs, nodes storing graphs and nodes connected with storing image files. In the future research this concept will be extended into distributed approach. Additionally, for gathering similar graphs of primitives in similar part of the network, K-Mean based clustering method is used.

This paper has the following structure: in the Sect. 2 the idea of graphs of primitives is described. The Sect. 3 describes the modified K-Mean clustering method and the Sect. 4 presents the concept of using a Multimodal Network for storing graphs of primitives. In the Sect. 5 preliminary experimental results are shown. The last section summarizes the idea and paper.

2 Graphs of Primitives

During previous works on Query by Approximate Shapes algorithm [5] different methods of sketch representation has been considered and as a result a representation using predefined set of shapes has been chosen. The set of predefined shapes can be defined as [5]:

$$T = \{L, A, PL, PG, Al, AL\} \tag{1}$$

where: O - a line, A - an arc, PL - a poly line, PG - a polygon, AL - a chain of connected arches, AG - a looped chain of connected arches.

For each of this predefined shapes we can define its property (e.g. for line its slope can be used or for an arc its angle), creating a primitive which can be defined as:

$$p_i = (t_i, a_i) : t_i \in T, a_i \subset A \tag{2}$$

where: t_i - primitive type, $t_i \in T$, A - a set of primitives attributes, defined as $A = \{a_{i1}, a_{i2}, a_{i3}, ...a_{in} : a_{i1}...a_{in} \in [0, 1], n \in N_+\}$.

In order to store mutual relations between primitives they are stored in a form of a modified graph, where each node is dedicated to one primitive and edges are used to represent connections between primitives. Additionally, the locations of primitives are stored using the geographical directions set K (containing following values: N, S, W, E and their combinations). The graph of primitives can be then defined as:

$$G_i = (V_i, E_i), \tag{3}$$

$$V_i = \{p_{ik} : p_{ik} \in P\}, \tag{4}$$

$$E_i = \{(p_{ia}, p_{ib}, k) : p_{ia} \in V_i \wedge p_{ib} \in V_i \wedge p_{ia} \neq p_{ib} \wedge k \in K\} \tag{5}$$

where: V_i - a set of nodes, E_i - a set of edges between nodes with information about their mutual location.

3 Gathering Similar Graphs of Primitives Using Modified K-Mean Clustering

One of the most common Unsupervised Machine Learning usage is finding clusters in a data which groups similar objects together. This task can be performed even for data which is with unknown classes but has similar properties.

The K-Mean clustering divides data into so called clusters which are groups of data points which have small variance with the centroid of the cluster. Mostly squared Euclidean distances is used to partition data. The K-Mean clustering in a modified version may be also used to gather similar graphs of primitives in clusters. In order to do that, two operations has to be defined: measuring the distance between two graphs of primitives and computing the mean of graphs of primitives.

Measuring the distance between two graphs of primitives may be defined as:

$$dist(G_1, G_2) = 1 - sim \tag{6}$$

$$sim(G_1, G_2) \in < 0, 1 > \tag{7}$$

where sim is a similarity of two graphs, which may be computed using different algorithms described e.g. in [4]. This implies that when two graphs of primitives are the same, the sim value is equal to 1 and the $dist$ is equal to 0. When two graphs of primitives are completely different, the sim value is equal to 0 and the $dist$ is equal to 1. For all other situations, the values $\in (0, 1)$.

Another operation which has to be defined for using K-Mean clustering for graphs of primitives is computing the mean graph of primitives, which can be defined as computing the average of each graph in cluster intersections:

$$G_m = avg(G_1 \cap G_2, G_2 \cap G_3, G_1 \cap G_3, ..., G_{n-1} \cap G_n) \tag{8}$$

where: G_1, G_2, ... , G_n - graphs of primitives for which the average graph has to be computed.

The intersection of two graphs of primitives G_1 and G_2 can be defined as finding a set of vertices and edges which has the highest *sim* and lowest *dist* coefficients with both G_1 and G_2 graphs:

$$G_1 \cap G_2 = \begin{array}{rl} \min\limits_{G_m,\xi} & dist(G_1 \cap G_2, G_1) + dist(G_1 \cap G_2, G_2) \\ \text{s.t.} & dist(G_1, G_2) \leq \xi \\ & dist(G_1 \cap G_2, G_1) \leq \xi \\ & dist(G_1 \cap G_2, G_2) \leq \xi \\ & \xi \geq 0 \end{array} \tag{9}$$

where: ξ - the maximum distance between two graphs of primitives which are considered as similar.

In order to compute average graph of primitives, there should be also defined the *avg* operation as follows:

1. Create empty average graph of primitives G_{avg}.
2. For each mean graph G_{m_i} given by parameter to $avg(G_{m_1}, G_{m_2}, ..., G_{m_i}, ..., G_{m_n})$:
   (a) for each pair of vertices $v_{m_{il}}$ and $v_{m_{ik}}$ and edge between them $e_{m_{ilk}}$ of G_{m_i}:
      (i) check if at least a half of other mean graphs contains similar vertexes and edges as $v_{m_{il}}$ and $v_{m_{ik}}$ and $e_{m_{ilk}}$ (compute *sim* using Eq. 7 and check if obtained value is $\geq (1 - \xi)$)
      (ii) if the condition is met, add $v_{m_{il}}$ and $v_{m_{ik}}$ and $e_{m_{ilk}}$ to G_{avg} if they are not present in the average graph.
3. return G_{avg}.

An example of K-Mean clustering for graphs of primitives is presented in the Fig. 1. The step 1 is dedicated to choosing randomly from existing graphs means - initial centroids for clusters. Next in the Step 2 the distances using Eq. 6 is computed and depending on results all graphs are assigned to each cluster. In the Step 3 new centroids are computed for each cluster: for cluster 1 - new graph of primitives is created as a mean of all graphs from the cluster, using Eq. 8, for cluster 2 - because there is only one graph in this cluster, the mean remains the same. In the Step 4 distances are computed using new centroids and all graphs are assigned according to the results. Next, in the Step 5 new centroids are computed (because there are no new mean graphs of primitives for centroids, all centroids remain without changes). After that, in the Step 6 distances are computed and assignments to clusters are made. Because there are no changes, the algorithm converges and finishes.

4 Multimodal Network for Query by Approximate Shapes

Multimodal Networks are very powerful tools for representing mutual dependencies between nodes which are hard to cover using classical graph or tree representation.

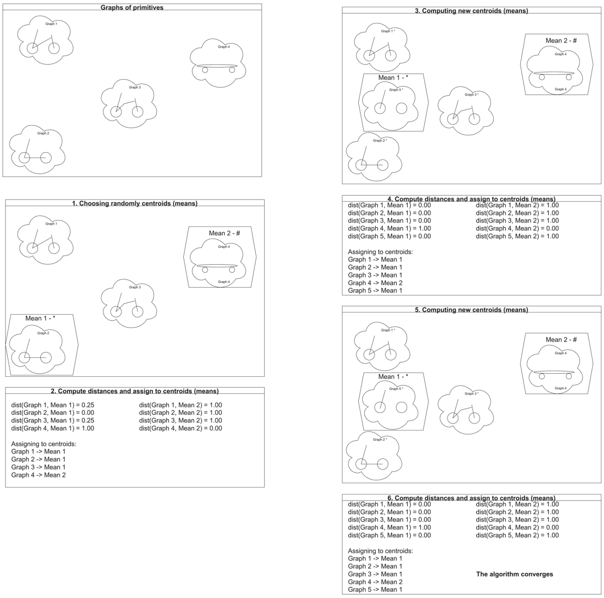

Fig. 1. Example of K-Mean clustering for graphs of primitives.

Table 1. The results of K-Mean clustering.

Iteration	Graphs in cluster 1	Graphs in cluster 2	Graphs in cluster 3	Graphs in cluster 4
0	–	–	–	–
1	1, 5	2, 3, 4	6, 7	8, 9, 10
2	1, 5	2, 4, 6	3, 7	8, 9, 10
3	1, 5	2, 4, 6	3, 7	8, 9, 10

In this work only preliminary approach was considered, but in the future more advanced properties of Multimodal Networks will be considered. Additionally distributed processing for Network will be taken into account.

The architecture of the Multimodal Network was designed in order to preserve all elements which are needed for Query by Approximate Shapes algorithm: information about objects graphs of primitives, their connection with image files and also mean graphs of primitives in order to gather similar graphs of primitives together. Because of that, there could be defined following types of nodes: entry node - a node used at first when traversing the network nodes, mean graph of primitives - a node which is dedicated to gathering common parts of other graphs stored in the network, cannot store connections to image files, object graph of primitives - a node which stores graph of primitives of objects present in image files, image file node - a node which is dedicated to storing one image file (the file physically may be stored in different ways e.g. in the memory or as a link to file on a disc), graph of primitives - is a special set of nodes which has the structure described in Chap. 2 and is a part of Multimodal Network.

In order to cover different types of nodes, there should be also defined different types of edges: from entry node to mean graphs of primitives nodes, from mean graphs of primitives nodes to objects graphs of primitives nodes, from means and objects graph of primitives nodes to graph of primitives, from objects graphs of primitives nodes to image file nodes.

An example of proposed Multimodal Network architecture is presented in the Fig. 2. The Node number 0 is an entry node, thus it is the first node which is entered after start traversing the network. From Entry Node there are present edges to Mean graph nodes (nodes: 1, 2 and 3). Mean graph nodes have edges to object graph of primitives nodes (nodes: 4, 5, 6, 7, 8, 9). Both mean graph nodes and object graph nodes have connections to adequate nodes in graph of primitives nodes set. Object graph of primitives nodes may be connected to one or more image file nodes (e.g. like in nodes 4, 10 and 11, where the same object appears in two different image files). Moreover, there could be also similar case when one image file node is connected to different object nodes (e.g. like in nodes 12, 5 and 6, where the image contains two different objects).

The major disadvantages of proposed approach are: long new images/graphs addition time caused i.e. by inner structure reorganizing (which may be a problem for some applications) and problem with storing huge amount of data. Both drawbacks will be investigated in future research, which may include using some distributed approaches both for speed increase and storage efficiency.

5 Preliminary Experimental Results

Thus, the Multimodal Network usage for Query by Approximate Shapes is an initial concept, only preliminary experiments were performed for testing the usability of K-Mean based clustering algorithm. The tests were performed for a set of 10 different graphs of primitives which are shown if the Fig. 3 and 4 clusters. The test results are presented in the Table 1. As an initial centroids for the 0 iteration following graphs has been chosen: Graph no. 1, Graph no. 3, Graph no. 7, Graph no. 9 (all centroids after each iteration are shown in the Fig. 4). For each

Table 2. Preliminary real life example results.

Object	Query by approximate shapes		Regions		Kato et al. [10]	
	Precision	Recall	Precision	Recall	Precision	Recall
Car 1 (Fiat 500)	0.89	0.33	0.53	0.75	0.58	0.83
Car 2 (Mercedes Benz)	0.79	0.73	0.51	0.5	0.47	0.7
Bike	0.93	0.37	0.23	0.42	0.4	0.5
Scooter	0.86	0.40	0.75	0.4	0.25	0.5