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MULTI-AGENT SYSTEM FOR CONTROL SOUND INFORMATION

Abstract: The multi-agent system for monitoring sound information (MAMS) in the environment is a set of agents for sound detection, analyzing, classification and transformation. The objective of this article is to propose a methodology from the detection of sound (specific agents) to the classification and decision making. In order to do the classification an agent must be implemented and regarding the situation it will generate a corresponding scenario. This agent will have as input, the sound, classification method, and the environment characteristics. Based on the information about environment the same sound can have different interpretation. MAMS implements the functions to ensure the required class of protection of people (working or living) and allows implementing an environmental safety system. The classification agent in MAMS can handle noise levels in the urban space and help in learning noise pollution of various areas: inside the building, in a public park or around the entire area, increasing the protection of the space to the required level. A conceptual schema will be automatically enhanced in the transformation agent in order to help in decision making.

Key words: sound level, sound information, multi-agent system.

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МУЛЬТИАГЕНТНАЯ СИСТЕМА УПРАВЛЕНИЯ ЗВУКОВОЙ ИНФОРМАЦИЕЙ

Аннотация: Мультиагентная система мониторинга звуковой информации (МАМЗ) в окружающей среде представляет собой набор агентов для обнаружения, анализа, классификации и преобразования звука. Цель данной статьи - предложить методику для контроля звука при классификации и принятии решений. Для того, чтобы выполнить классификацию агент должен быть реализован и выполнять соответствующий сценарий. Этот агент будет иметь в качестве входных данных звук, метод классификации и характеристики окружающей среды. На основе информации об окружающей среде один и тот же звук может иметь различные толкования. МАМЗ реализует функции по обеспечению необходимого класса защиты людей (работающих или живущих) и позволяет реализовать систему экологической безопасности. Агент классификации в МАСЗ может оценивать уровни шума в городском простанстве и помочь в изучении загрязнение шумом различных областей: внутри здания, в общественном парке или вокруг всей области региона, приводя защиту простанства к необходимому уровню. Концептуальная схема будет автоматически регулироваться агентом преобразования, чтобы помочь принятии решений.

Ключевые слова: уровень звука, звуковой шум, мульти агентная система.

1. Introduction

Measuring, registering, analyzing and classifying the various levels of sounds and their effect on the surrounding areas are a very complex process. In fact, the amplitude and effect of sound waves vary considerably across the continuous spatio-temporal dimensions. For instance, the noise produced by a taking-off airplane is perceived by its neighborhood with varying amplitudes over time: it starts loud, and then decreases gradually while it is flying away. On the other hand, modeling of data and especially spatio-temporal data is an important phase that gives the users a clear way to understand a case study and to do some decision making. In fact, a conceptual spatiotemporal data model must be able to offer users a wealth of expression to meet their diverse needs and also enable them to implement readable and easy to understand data schemes. In order to properly model spatiotemporal data, some requirements, besides those related to traditional data modeling, must be taken into account during the design phase. In fact, the conceptual model should allow [1,2,3].

- Modeling of spatial and temporal dimensions as well as the temporal evolution of objects (history tracking).
- The orthogonality between the structural, spatial and temporal dimensions is to say that a choice of representation in one dimension does not limit the choice possibilities in another dimension.
- Modeling, in a realistic way, objects and events that occur in a field of study, along with their interactions.
- Multiple data representations that include multiple resolutions (scales of different maps) and numerous points of view (based on the user's profile).

Modeling of sounds can be viewed as a part of spatiotemporal modeling, but in addition to the characteristics of spatio-temporal data the registration and measurement of sound and their spatio-temporal effects is complexes and need specified detectors and mechanism.

A Multi-Agent System (MAS) is one of the agent technologies where a group of independent agents that are not connected to each other, works together in an environment to get a common target. This is done either by competing or cooperating with each others, or by sharing information or knowledge that might help to reach a specific goal.

In this article we will present in section 2 a state of the art of MAS, sound classification and the conceptual spatio-temporal models. In section 3 we will present our methodology for manipulation of application that include the sound dimension.

2. Related works

Multi-agent systems (MASs) have been usually accepted and imbedded in deferent domains applications because of their benefits and advantages that they can offer. Some of these advantages or benefits that offered by using Multi-agent systems (MASs) in large systems are:

1. An enhance in the effectiveness and speed of the process due to parallel computation and asynchronous operation.

2. In case of degradation of the system (when one or more of the agent fail), common reliability and robustness of the system is not less.

3. Scalability and flexibility - Agents can be added as and when necessary.

4. Reduced cost - this is because individual agents cost much less than a centralized architecture.

5. Reusability - Agents have a modular structure and they can be easily replaced in other systems or be upgraded more easily than a monolithic system.

The most important classification methods use Hidden Markov Models (HMM), Gaussian Mixture Models (GMM) and Support Vector Machines (SVM), which are discussed in below, although there are other useful methods that are summarised as follows [3]:

***k*-Nearest Neighbours (*k*-NN):** a simple algorithm that, given a testing pattern, uses the majority vote of the *k* nearest training patterns to assign a class label. It is often described as a lazy algorithm, as all computation is deferred to testing, and hence can have a slow performance for a large number of training samples. For the case of the 1-NN, the method has a 100 % recall performance, which is unique.

Dynamic Time Warping (DTW): this algorithm can find the similarity between two sequences, which may vary in time or speed. This works well with the *bag-of- frames* approach, as it can decode the same word spoken at different speeds. However, it has largely been superseded by HMM for Automatic Speech Recognition (ASR).

Artificial Neural Networks (ANN): this method, also referred to as a Multi-Layer Perceptron (MLP), is a computational model inspired by neurons in the brain. Given a sufficient number of hidden neurons, it is known to be a universal approximator, but is often criticised for being a black-box, as the function of each neuron in the network is hard to interpret. It also suffers from difficulty in training, as the most common method of back propagation is likely to get stuck in local minima.

There are many features that can be used to describe audio signals. We have examined some of them in the previous section. The feature vector for the experiments consisted of features summarized in Table 1:

Table 1: List of features used in classification ”University of Southern California, Los Angeles, CA 90089, USA”.

Feature No.	**Types of Features**	**Feature No.**	**Types of Features**
1-12	1st – 12th MFCCs	**31**	Energy Range, Er
13-24	Standard Deviation of 1st – 12th MFCCs	**32**	Standard Deviation of Energy Range
25	Spectral Centroid	**33**	Frequency Roll-off
26	Spectral Bandwidth	**34**	Standard Deviation of Roll-off
27	Spectral Asymmetry	**35**	Spectral Flux
28	Spectral Flatness	**36-45**	Relative energy when the concentration of the power is greater than 75% (for the first 10 frequency bands)
29	Zero-Crossing		
30	Standard Deviation of Zero-Crossing		

Several spatiotemporal modeling approaches that take into account these exigencies have already been proposed [4]. Most of them are based on modeling techniques used for traditional data modeling like Entity-Association (EA) and Object-Oriented (OO) approaches.

Among the models of the OO approach we can note STUML "Spatio-Temporal UML” [7] and Perceptory [5], which are based on UML (Unified Modeling Language)

[6]. Perceptory, for example, provides support (as icons) for spatiotemporal properties. The spatial and temporal properties can be used simultaneously, and can be assigned to classes and to attributes. Its main weak point is that it does not assign spatial nor temporal properties to associations between the objects of a conceptual model.

Among the models of the EA approach we can also cite STER (Spatio-Temporal Entity-relationship) [8] and MADS (Modeling of Application Data with Spatiotemporal features) [3]. STER allows treating complex geographic features and gives the possibility to create spatial and temporal relationships between these entities. However, it does not permit to describe multi representation of data.

As for MADS, it allows the representation of real world entities as objects and associations. It supports orthogonality between the structural, spatial and temporal dimensions. It has intuitive and very readable visual notations to represent spatial and temporal concepts, as well as a specific language to query the data model.

MADS have a multi-perception and multi-representation features, enriched by the object-oriented structure that has multiple advantages like inheritance, effective manipulation of temporal data, and uniform handling of spatio-temporal data. MADS also solves the fundamental issue of how to add the space and time dimensions by representing the modeling dimensions orthogonally. The orthogonality of its three dimensions (spatial, structural, and temporal) allows the association of a spatial or/and temporal dimension to any element in the model [9]. It is composed of:

- a Spatial Dimension: provided for shape and location information; it includes representation of points, lines, and simple areas, etc.

- a Temporal Dimension: it includes representation of instants, intervals, and temporal elements, etc.

- a Structural Dimension: it allows schema designers to represent basic concepts from extended entity-relationship modeling, e.g., objects, Integrity constraints, links, etc.

- Multi-representation features: to allow users to retrieve specific representations from the set of existing ones. Multiple representations have to be distinguishable. The redefinition described in the structural dimension of MADS allows for example to describe multiple spatial representations, one for each of its classes in the generalization / specialization hierarchy.

The figure 1 shows MADS's conceptual model for a road seen as a line in a first point of view or representation (r1) and as a simple area in the second one (r2). The attribute "roundabout" is specific to the second representation, while the other attributes "id" and "name" are present in both representations.

Also note that the road's name is a "perception varying-attribute" whose value changes according to the view. MADS has been already extended to represent spatio-temporal events [10]. The work in [11] also proposes a transformation of MADS models into an Object Oriented language, namely Java, which preserves the semantics of the original model and provides at the same time a mean to query, visualize and reason on the modeled spatio-temporal objects.

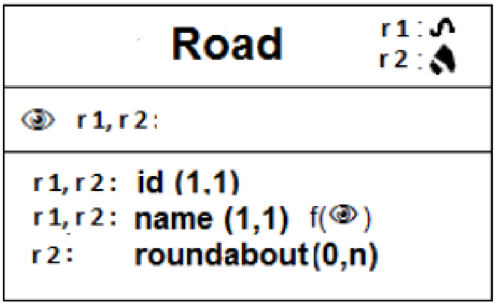

Figure 1 : MADS road

In [12], MADS is extended to offer a modeling tool that allows to augment GIS conception with a new dimension that represents sounds. The contribution in [12] builds on the orthognality feature of MADS to allow the designers to put the information related to the sounds in the class or attribute level. The road specified in the figure2 is augmented with a "sound" attribute. The model is also able to represent the different types and variations of sounds over time and space scales, taking into consideration continuous, occasional and periodically repetitive sounds.

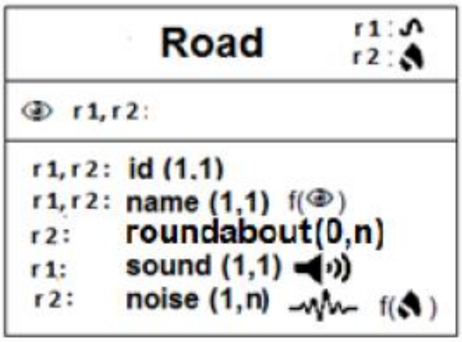

Figure 2 : MADS road with sound attribute

3. Our approach: MASMSI

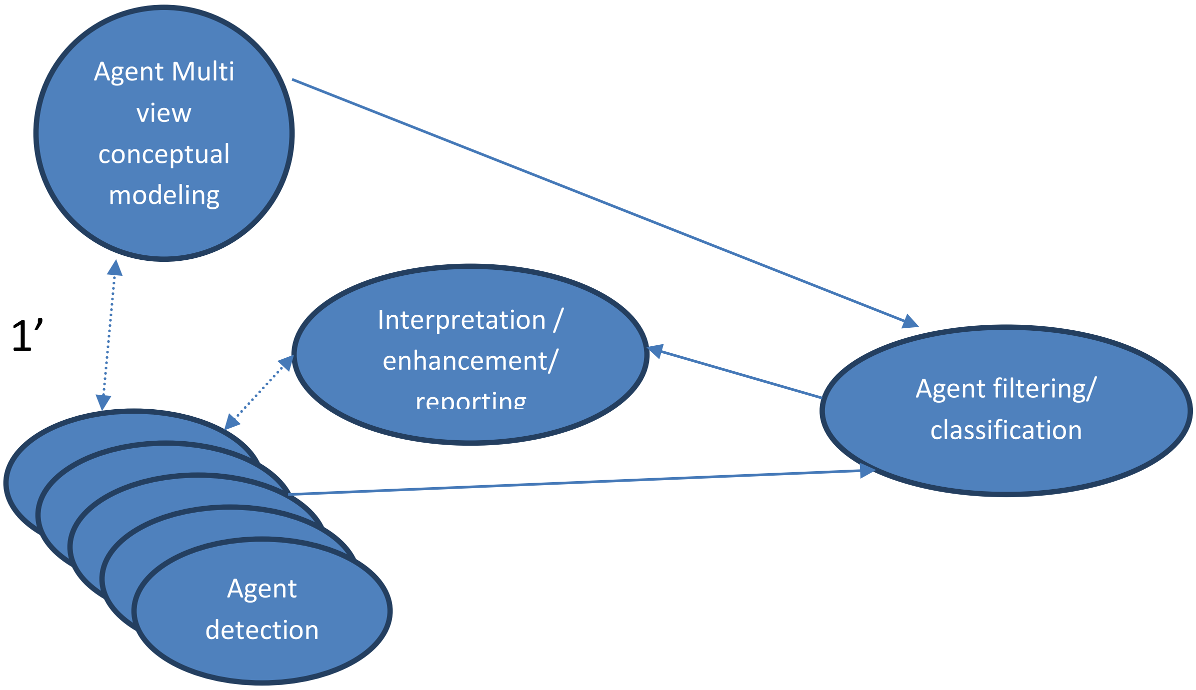

Figure 3:Multi-agent System for Monitoring Sound Information (MASMSI)

The multi-agent system for monitoring sound information (MASMSI) is composed of four different agents that works together to get the required output. The process of MASMSI has several algorithms.

The first methodology starts from the Detection agent that send information to the Filtering and Classification agent which will also get information from the Multi View Conceptual Modeling agent and then send it to the Interpretation/Enhancement/ Reporting agent (Database and Graphical User Interface "GUI").

The second methodology have the same cycle as the first methodology, but in this case if there is some information missing so the Interpretation/ Enhancement/ Reporting

Agent will get back to the Detection Agent to get the needed information, and then the cycle will complete as the first methodology to get a better result.

The third methodology also has the same cycle as the first methodology but before the Multi View Conceptual Modeling Agent give information to the Filtering and Classification Agent it will communicate with the Detection Agent and get the required information.

We would like to stress the fact that the "Multi-view Conceptual modeling Agent" does not replace the work of experts in acoustics. It is simply a tool for those experts interested in studying urban sounds and their effects. In fact, the expert has only to design a model that reflects a specific case study, and then our framework shall transform the model into an exploitable and automated system.

4. Conclusions

We present in this article an outline and methodology for MAMS as a perspective of this work we will focus on each agent and we will do each implementation, a solution that would be practical for the end user. We will do the implementation within the next steps; we will focus on each agent separately and focus on each study and implementation. The detailed plan includes:

1. Creating a hierarchy for conceptual representation and a complete set of pictograms to cover all noise types of sound.

2. In the transformation agent will focusing on creation of decision tree in order to swap between scales.

3. Regarding the specific types of sound different types of detectors will propose the suggestion for the related sound detectors.

4. The last agent will be used as GUI graphical user interface that create automatic report for the end user.

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