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BIRD MONITORING SYSTEM - RECIPROCAL DATABASE

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ABSTRACT

The system which can monitor bird species based on automatic bird voices recognition is very useful in order to protect biodiversity of avifauna. In the paper database system together with an expert system and a recognition unit are described. Recognition unit (recognizer) recognizes bird species and bird communication signals from the digital signal registered in digital audio recorder. Information about bird species and communication system obtained from recognizer supported by an expert system is stored in the database system. Some initial results of recognition experiments are also given.

Key Words: bird voices recognition, database system, expert system, rule based system, data mining.

1. Introduction

Environmental protection becomes nowadays more and more important issue in government policy of many countries. One of the crucial aspects of this policy is protection of avifauna biodiversity. In order to protect bird species especially endangered with extinction an acoustical bird monitoring system can be created.

Block diagram of the acoustical bird monitoring system has been shown on the figure 1. This system combines electronic devices gathering various data with database system storing the information. Entering sound information to the system is supported by recognizer with expert system. Parts marked with grey: database, expert system and recognizer are described in the presented paper. General concept of the system, bird observation methodology and some analyses of selected birds species voices has been described in [1], Electronic equipment is described in [2].

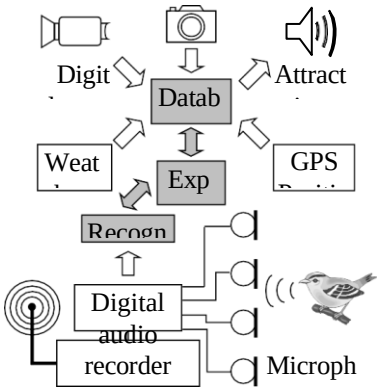

Fig. 1. Block diagram of the Acoustical Bird Monitoring System (ABMS)

2. Software overview

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Recognizing signals which are precisely and correctly separated into distinct classes is mostly done by a closed, non-adaptive systems whereas recognizing signals which classification is not well known or may change should be processed by an open, adaptive systems.

Closed, non-adaptive recognizing systems rely on predefined and, in long period of time, immutable number of classes.

It entirely stored locally (i.e. within recognizing program). There is no necessity of interaction with any external, remote system which serves database with patterns. Moreover, signals which are entered to the system are not added to the database and cannot be used in recognition afterwards. Closed non-adaptive systems have a lot of drawbacks. First of all accuracy cannot be improved on recognized signal basis, it can be done only by modifying, enhancing recognition algorithm. Moreover, knowledge which is delivered with recognized signals is not analyzed, not drilled and eventually lost.

Open, adaptive systems are devoided of mentioned disadvantages. Such systems are working with dynamically changing number of classes and patterns. Pattern database, in most cases, is also defined extensionally. In contrast with closed systems, in open ones, apart from patterns, database contains also signals which were processed and recognized, correctly or not. Since every entered and processed signal is stored, database size is continuously increasing thus it implies necessity of storing data externally (e.g. outside of recognition application). Splitting the system into **recognizer** and **database** subsystems requires communication protocol. Communication between recognizer subsystem and database subsystem in ABMS is implemented with TCP/IP (Transmission Control Protocol/Internet Protocol) and QPSQL (Qt PostgreSQL) driver. The new data with using of intesional representation can be used to extend existing patterns database automatically or under surveillance. Intensional representation can be determined directly by rules or indirectly with use of classifiers (neural networks, naive Bayes). Classification and also clusterization methods are supposed to be implemented in **data mining engine** subsystem. Open, adaptive systems characterizes medium or big number of patterns, therefore recognizing is time- and resources-consuming process. The problem can be alleviated by introducing preselection method, which selects only a subset of patterns from database. Exclusively preselectioned patterns are used in recognition.

Preselection can be done based on signal parameters [3] or based on context information and metadata. In ABMS both preselection techniques are used.

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Signal parameters preselection uses values which are computed for recognized signal. Context and metadata preselection uses information and data associated with recognized signal. The system utilizes both universal and domain specific information and metadata. An **expert system** with uses of knowledge base and inference engine is responsible for preselection based on metadata and context information.
On figure 2 subsystems responsible for recognition, storing and managing information, patterns preselection as well as data mining in an open, adaptive ABMS are depicted.

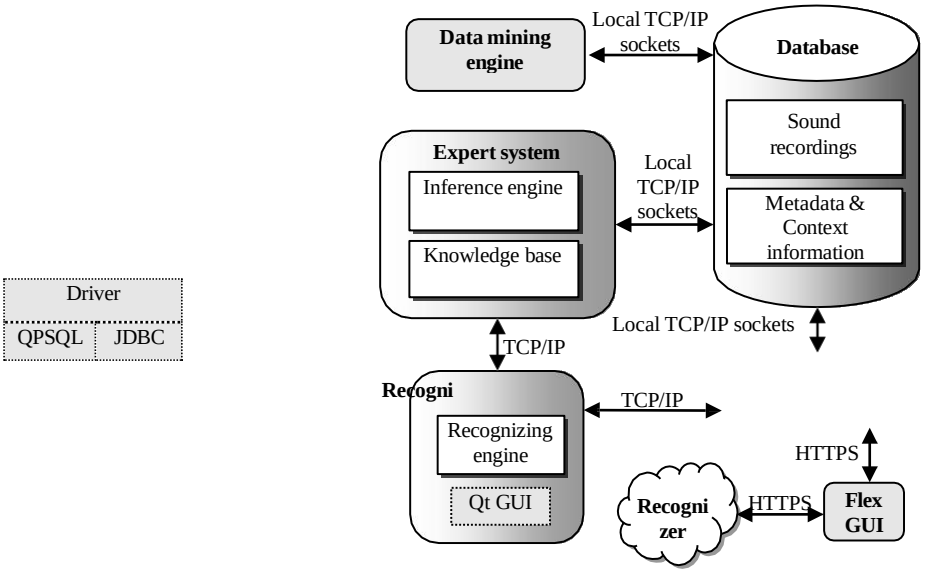

Fig. 2. Block diagram of ABMS subsystems responsible for recognition, storing and managing information, patterns preselection and data mining

2.1. Recognizer

There are different recognition methods. In case of bird voices recognition the most reasonable methods seem to be dynamic time warping (DTW) [4] or hidden Markov models (HMM) [5]. These methods allow not only bird species recognition but also the type of bird communication signal identification.
Recognition process consists of following steps:

1. Signal detection which is usually based on energy threshold method. Signal detection rather do not extract exactly the signal to be analysed but can minimize further computation effort by removing signals of too low energy level. Automatic signal

detection can be replaced by manual estimation of signal endpoints in supervised mode of recognizer.

2. Preselection step which allows to calculate signal parameters like signal length, X coordinate of squared signal mass center, X coordinate of squared FFT mass center, signal-to-noise ratio. These parameters can help decrease significantly the number of patterns or recognized class what gives lower number of wrong recognitions and can shorten the recognition time [6]. The preselection method is good for supervised mode of recognizer. Using the preselection method in unsupervised mode of recognizer is difficult because the exact endpoints of signal are not known.
3. Feature extraction usually based on Mel frequency cepstral coefficient (MFCC) method [7]. The newer method which proved to be better than MFCC in bird voices recognition is Human factor cepstral coefficients (HFCC) [8].
4. Classification method which can be DTW or HMM method. DTW is usually used in its word spotting form which allows to recognize the signal without signal detection. HMM method in case of bird voices recognition uses whole-word Markov models.

Performance of the recognizer has been initially tested giving maximal about 96% accuracy for HFCC and about 90 % accuracy for MFCC in closed set of experiments [8]. DTW method has been used in the experiments. Some research concerning preselection methods has been done as well. Some of the preselection methods yield good results but further research is necessary [6].

2.2. Expert System

In ABMS an expert system provides additional support in preselection process based on metadata and context information. There is used rule-based representation formalism. Knowledge base is built on the basis of ornithologists expertise but can also be discovered with an expert system. The inference mechanism is based on a forward

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chaining strategy. The strategy searches the knowledge base until it finds a rule where the antecedent is known to be true. After any rule is found the consequent is obtained and therefore the conclusion can be made. Examplery rules of ABMS are shown below:

R1: IF observation_date BETWEEN first_day_of_october AND last_day_of_march THEN NOT White_Stork (Confidence factor: 90%);

R2: IF height_of_bird < 100 cm OR height_of_bird > 125 cm THEN NOT White_Stork (Confidence factor: 95%);

In ABMS Prolog logic programming language were chosen.

2.3. Database

The ABMS system is implemented with MVC (Model-View-Controller) architectural pattern. Database, represented in MVC architecture in model tier, describes entities as well as relationships between them. Database model represents two categories of information:

- encyclopedical data;
- experimental data.

Encyclopedical data includes well-known knowledge about bird species, especially taxonomy, appearance and anatomical features, usual habitats and nutrition, typical singing time, approximated migration and breeding dates as well as voice characteristics. Experimental data includes information which are gathered during observations. Since there were proposed precise procedures, defining how data during observations are collected, database had to be adopted for storing information coming from different sources and with distinctive structure. Some of the procedures are used for observations with audio recording, some of them are used for presence of species ascertainment and the other ones are used for bird counting. All procedures delivers very useful information which are utilized by recognizer, especially in preselection process but also in data mining.

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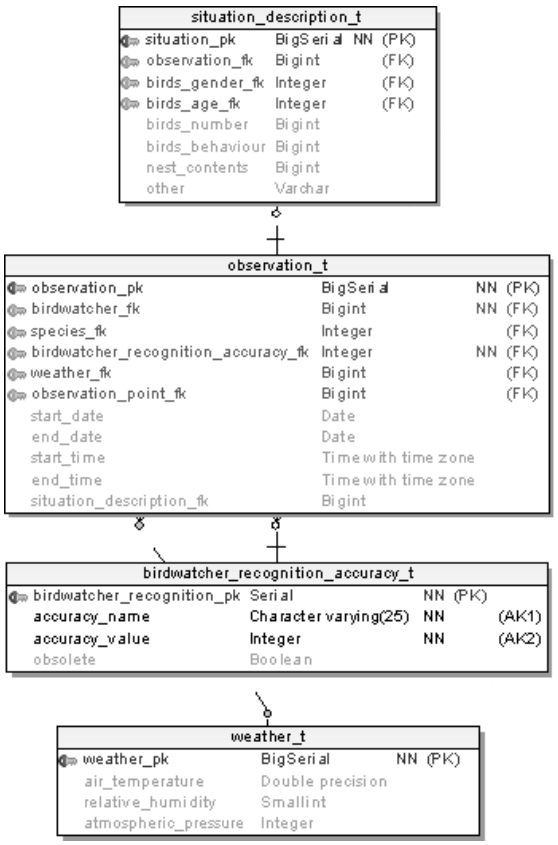

Fig. 3. A part of ERD (Entity Relationship Diagram) of ABMS representing selected context information relating to bird observations

In ABMS PostgreSQL DBMS (Database Management System) were chosen.

2.4. Data Mining Engine

Data mining engine is used to extract hidden, concealed knowledge from entered sound recordings and metadata, context information. Techniques of classification and clusterization in data mining process are used. Since the mining process is ineffective if the sound recordings as well as metadata and context information sets are not a good representation of the sets universum it is necessary to gather as much sound recordings, metadata and context information as possible. Therefore there is proposed alternative path of collecting information. Besides entering alphanumerical (e.g. text, numbers) and multimedia data via recognizer, alphanumerical data can be entered via internet browser and application implemented with **Flex** and **Java** technology. Java technology represents second tier (i.e.

domain logic) in MVC architectural pattern, whereas Flex technology represents third tier (i.e. user interface view). In data mining, classification with neural networks or naïve Bayes could be used to determine preselection based both on signal parameters as well as metadata and context information. Classification based on metadata and context information is source of experimental knowledge which, after formalization, can formulates new rules in an expert system.

3. Conclusion

Using complex, heterogeneous systems which consist of many components outperforms traditional, homogeneous ones because each subsystem provides various techniques, methods and algorithms which can be used in recognition, improving overall accuracy. The main problem which authors coped with was integrating that different subsystems together. Based on authors experiences technology choice should be very carefully investigated at the beginning since it determines consequent capabilities of whole system. As it is presented in the paper integrating PostgreSQL database with applications implemented with JAVA, C++ (domain logic) and Flex, Qt GUI (Graphical User Interface) as well as PL/pgSQL language for data mining and Prolog for expert system, guarantees flexibility, scalability and satisfying performance of the system.

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Agnieszka Lisowska-Lis PhD eng, is a biologist in the Polytechnic Institute at the SHVS in Tarnow, Poland. During the period 1989- 1995 she studied in the Department of Animal Biology and Husbandry at the Agriculture Academy in Krakow, finishing her MSc in Animal physiology. She also undertook additional studies in biochemistry, endocrinology and zoology in the Biology Dep. at Jagiellonian University in Krakow, as well as short course at the Scottish Agriculture College, Auchincruive, UK with diploma work on Milk malabsorption and allergies. After completing her studies she worked for one year in the Animal Breed and Breeding Department at the Animal Husbandry Institute in Balice. That work was dedicated to freezing animal embryos. Her PhD Study was carried out from 1997 to 2001 and focused on waste utilization, as well as educational work in the ecological background of the Environmental Engineering Dep. and Animal Biology and Husbandry Dep. Agriculture

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