Distributed System for Intelligent Management of Lost or Abandoned Pets

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ABSTRACT

This paper presents the architecture of a mobile-based distributed system which aims to minimize the social impact of abandoned or lost animals. To reach this purpose the distributed system has two main goals: to obtain the best pets' quality information and to optimize the reporting process that allows their rescue. The distributed system is based on the client-server paradigm. By using smart mobile devices clients may provide message warnings of animals localized. In order to enter data such as photographs, audio and artificial images, this system uses different mobile device interfaces. Messages with the pet information are stored in a server database to be processed intelligently. Data processing consists mainly in matching localized animals with lost animals, assigning abandoned animals to shelters and generating notifications for animal shelters or authorities. This matching uses an efficient selection algorithm based on common meta-information to each image. This efficient selection facilitates selective notification deliveries avoiding redundancy. This article shows the architecture details, as well as the first achieved results with prototypes and real data.

Keywords: Distributed system, meta-data, system optimization, lost and abandoned pets.

Mathematics Subject Classification: 68M14, 68U01

Computing Classification System: C.2.4

1. INTRODUCTION

When an animal is abandoned or lost (LAP), as well as the animals own tragedy, a series of targeted events are fired for the rescue. In case of an abandoned animal, Animal Protection Societies (APS) are the ones seeking to locate it. For a lost animal, the owners are also concerned.

In most countries, legislation penalizes animal abuse and neglect. However, animal loss or abandonment is a current problem in some communities. Numerous associations work in communities to help animals, either welcoming in animal shelters or finding them a new home. APS lack common information, databases and channels to receive animal warnings and notify the news.

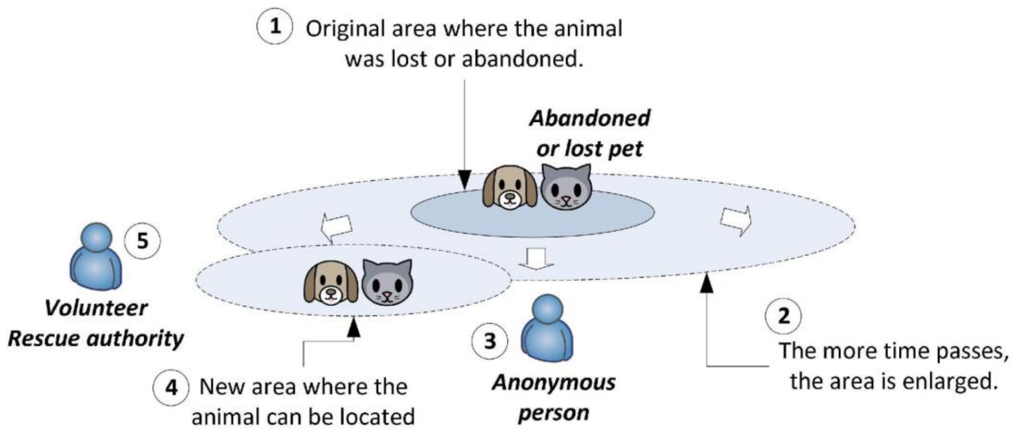

Figure 1. Simplified view of the problem of locating a lost or abandoned pet.

Figure 1 shows a simplified version of the problem that is solved with the system presented in this paper. The main problem is that a LAP has a wandering behaviour since the moment it has been lost or abandoned (Figure 1, point 1). As time goes by, the LAPs location area where they can be found increases (Figure 1, point 2). This increased area complicates LAPs location because more people are needed to locate it or otherwise the entire location area won't be covered. However, if someone locates the animal (Figure 1, point 3) the location area where it's possible to found them greatly decreases (Figure 1, point 4) and APS volunteers (Figure 1, point 5) can come to the rescue without using more available resources. Therefore, to timely warn the APS about a spotted animal and the APS information and location record collation, allows an optimized process and so the corresponding social and economic benefits.

Smart mobile devices, cloud computing and data storage optimization can provide technological support to APS in the process described. Currently, sending information about a lost pet can be easy by using a mobile device because of they have photography camera and microphone. Besides, these devices allow sending geospatial and temporal data. It is possible to optimize the location of the pet's owner, or an adopter, through data-matching by using a distributed data system. In order to do this, it is necessary to use unified data and to synchronize correctly different data sources and destinations. However, the processing capacity of mobile devices is limited. To supply this lack a server is needed. Server performs the costliest processes (features extraction, data matching and data storage). The system presented in this paper aims to help APS to manage the animals and to optimize the location of owners or adopters.

This paper is organized as follows. Section 2 reviews the current state of the problem and current solutions found by the authors. Section 3 describes the system architecture components, method used to be implemented and the details of data flow and data processing in the client and in the server side. Section 4 disclosures the first experiments performed and the first results obtained in the beta system. Finally, section 5 exposes the current state and challenges for the future of animal management.

2. RELATED WORK

Several studies have been carried out about protocols that must be followed when either a lost animal or abandoned animal is found by someone (Lord et al., 2007). Most of these protocols insist specially on both the importance of information management (Weiss et al., 2012) and the huge possibilities of being applied into other technology fields regarding animal researches (Laplante, 2011). In order to follow these protocols, animal protection societies usually use web pages in which they can warn about a lost animal or offer one to adopt. Warnings get to the APS, which must publicize the loss. APS transmit the notice through their own web sites as well as in social networks. Currently notices are sent without checking whether lost animals have been located. Besides, users receive messages without picking the geographic area of interest as they can receive advises of lost animals that are located far away from the area to be searched.

The lost or abandoned animal notification management has many similarities with the emergency management as it involves the 90% of the same areas: communications, event detection, warning, GIS supported collaboration and decision support (Aman et al., 2012). Therefore, it seems appropriate to use the same emergency management methods for the lost or abandoned system management design. It is of special interest the use of the new technologies to optimize the entire process (Majchrzak and More, 2011). Some authors stand out the benefits of using mobile applications to locate lost animals (IFPUG, 2012). Concerning Android, there are about ten applications that are able to advice of a lost pet or abandoned one. Most of these mobile applications have a data insertion based on forms and they are adapted to specific data bases (Yun and Peiji. 2010).

Currently there are several algorithms that use artificial intelligence (Gao et al., 2012) to obtain several characteristics or to control several features (Precup et al., 2012). Current research uses these algorithms to optimize (Yazdani et al., 2013) an objective or to solve the problem of multiple objectives (Asawarungsaengkul et al., 2013). Lost or abandoned animals matching is a problem with some similitudes with the problems solved by means artificial intelligence algorithms. Based on the earlier premises, authors have designed (Garrote-Hildebrand et al., 2013) and developed a system based on mobile applications expecting to improve current systems that are described straightaway.

3. SYSTEM DESCRIPTION

For the animal location problem management, the system must provide different features: ease of use, variety and information being sent straightaway. Mobile devices are most suitable as they cover these characteristics (Ting et al., 2007). For the notices information and generating process it is convenient to use a powerful system, in this case a web server, a database server and an information processing server are combined.

3.1. System components

Figure 2 shows the system overview. The system has two types of users: Advertisers and Managers. Advertisers send warnings about abandoned or lost pets by means of a smart mobile device or a personal computer (step 1). Advertiser's mobile application sends two types of information: data about pet characteristics and metadata about the date, time, geo-location and user contact (step 2).

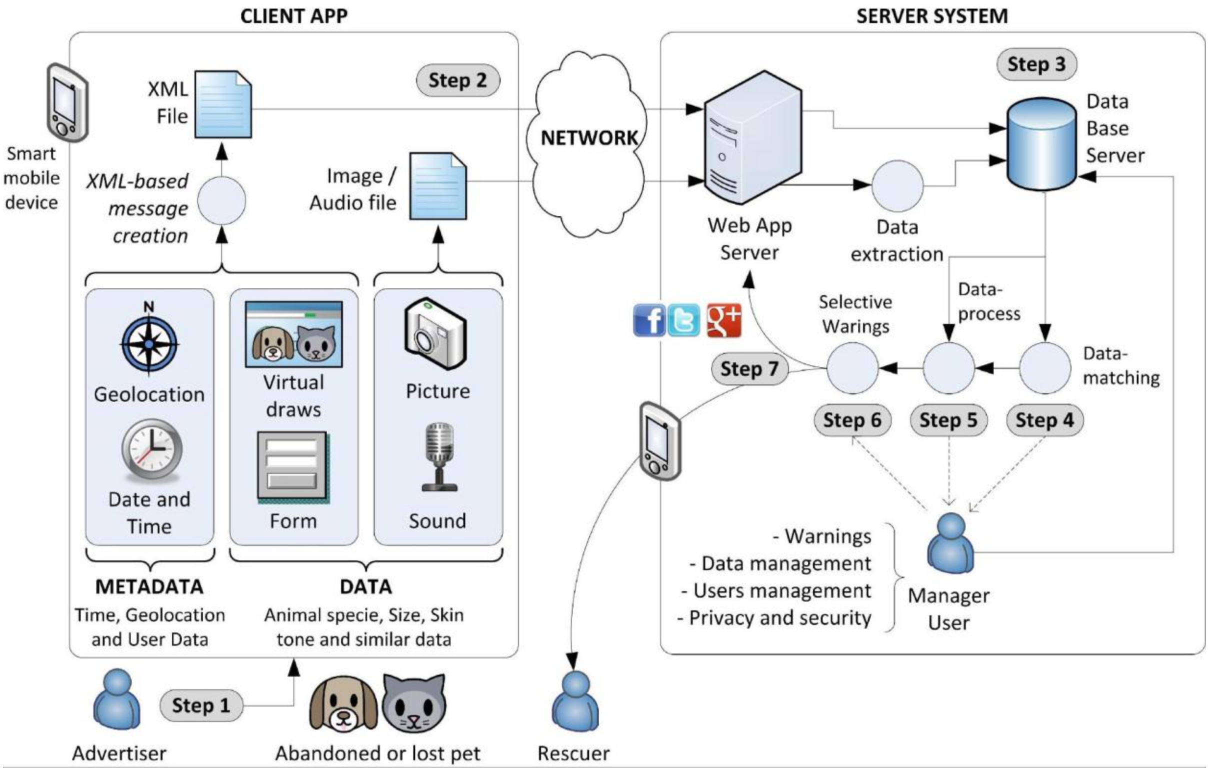

Figure 2. System overview with Advertiser Users (left) and Manager Users (right).

Metadata must be approved by the user. In the first version, the characteristics of animals to transfer are three: animal species (dog, cat, etc.), size and prevailing hair colour. A Web service receives data and stores it in the database (step 3). To send a photograph with a mobile device is the easiest method and it allows the manager to collate the photography with an existing animal, so it is important to include image recognition to facilitate the matching task. When received data is a picture or an audio, the server performs a pattern recognition process to extract the same terminology features that are stored in the database. The pattern recognition is a complex task (Bhagat, P. 2005).

When data is stored, system launches the matching process with the new animal data (step 4). The matching process returns both matching percentages: data one and metadata one. Data match result is used to determine if an animal exists in the database and to discard localized animals (step 5). If a result is above a threshold, the database sends a warning to a Manager User (step 6) that can determine and adds certainty to the result (step 7). Manager User, or system in automated mode, sends the message warning to the APS that is in the nearest place to the animal localized (step 8).

Metadata is automatically stored by the application. There are four methods to enter animal data: Form, Virtual Draw, Picture and Recorded Voice. Form is the classical method used by Web Applications and implies an effort by the user. To reduce this effort, the mobile application offers other three methods. Virtual Draws allows the user to model an animal by using only the touch screen. With the Form and the Virtual Draw the application provides directly the animal parameters.

Picture needs segmented, feature extracting methods and form detection. Recorded Voice requires keyword detection as “big dog” or “white cat”. Both processes are implemented in the server side. Data match is made directly with SQL queries and by means of Linear Discriminant Analysis (Azzalini and Scarpa, 2012)). Manager User monitors and increases results accuracy. The first prototype of the mobile application is developed in Java with the Android SDK provided by Google. In the server-side, the services applications are being developed in PHP with MySQL to provide the database support.

3.2. Data path

Collected data from the mobile application or obtained from the image or audio processing are classified into the following categories (Table 1). Table rows show the different features used in the database to find possible pet coincidences. Columns show the features that are easily obtained from each data source.

Table 1: Features of the data supplied by the application stored in the database and features provided directly (or obtained after processing) from the mobile application by each data source.

Features	*Values*	*Form*	*Virtual draw*	*Picture*	*Sound*
Animal Specie	Dog, Cat, Parrot, etc.	Yes	Yes	Yes	Yes
Size	Big, Medium, Small	Yes	Yes	Not	Yes
Prevailing colour	White, Grey, Black, Brown, Other.	Yes	Yes	Yes	Yes
Secondary colour	White, Grey, Black, Brown, Other.	Yes	Yes	Yes	Not
Skin/Hair pattern	None, Spotted, Striped	Yes	Yes	Not	Yes
Age	Puppy, Adult, Aged.	Yes	Yes	Not	Yes
Behaviour	Elusive, Aggressive, Sociable.	Yes	Yes	Not	Yes
Appearance	Healthy, Injured, Seriously injured	Yes	Yes	Not	Yes
Spatial location	GPS Coordinates, ZIP code and similar	Settings dependent			
Time location	Date and time				
User information	Nick and mobile data				

As seen in the table, only form and virtual draw allow to collect all features. However these methods take the most time and consume the largest number of touch gestures (basic gestures for the most touch commands) (Villamor et al., 2010). Moreover, pictures and sounds are the fastest methods, but both methods require previous processing to be stored in the database. Figure 3 shows the details of the data path into the system, and the average times (A.T.) obtained in the test phase. It can be seen that the obtained times depend of the input method.

The user can choose between four different methods to provide information about a lost or abandoned pet. The more information provided, the more accuracy will be obtained in the matching process. On the server side, the desirable characteristic is the uniformed information. To achieve data uniformity, server must process information depending on the type of source. Forms or virtual drawings do not need treatment because the characteristics are obtained directly from the client. However, pictures and voice recordings require a processing step to extract the largest amount of features as possible. The next subsection explains how this phase has been implemented.

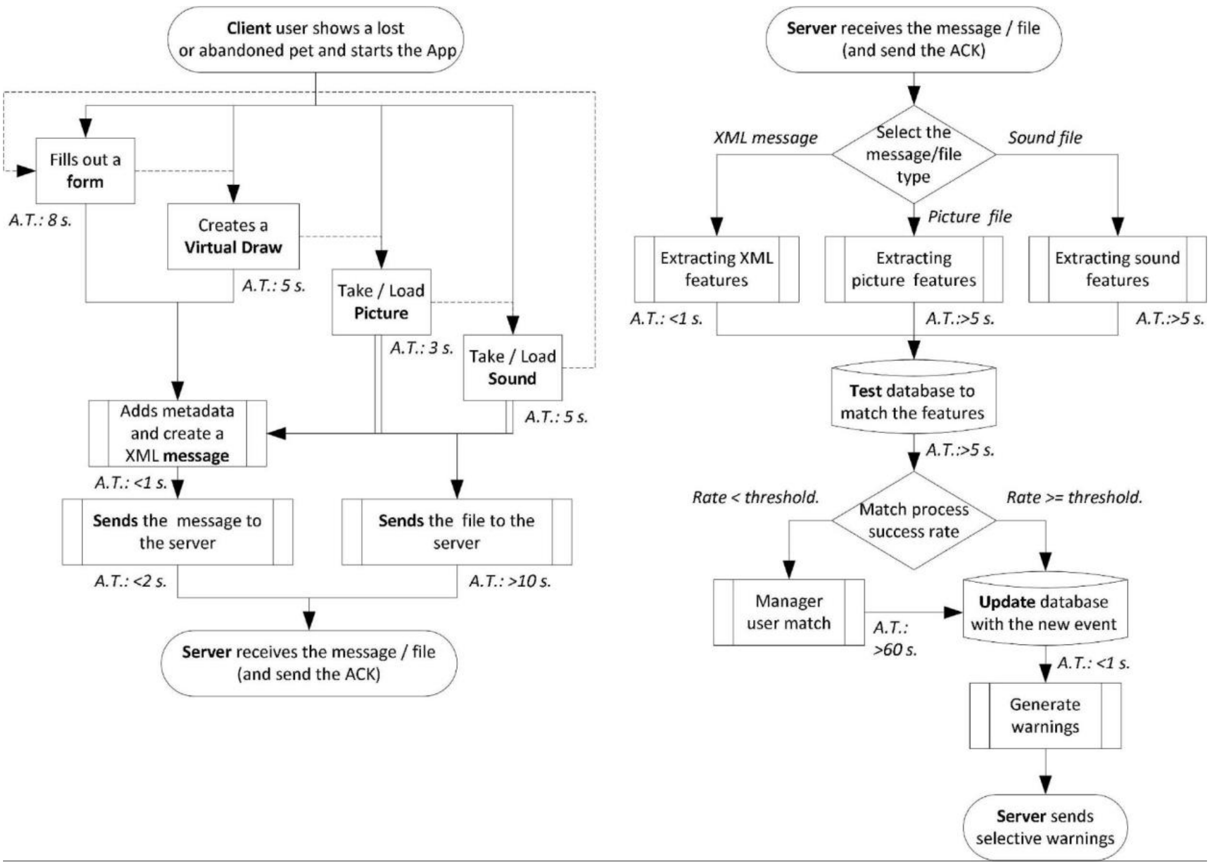

Figure 3. Flowchart of the different steps of data processing with the measured average times (A.T.) obtained in the test phase.

3.3. Data processing and data matching

There are two important phases inside the server: processing and matching data. Processing is performed by external libraries. In the case of the pictures, we use a local C++ program with the OpenCV library (Laganiere, 2011) called directly from the web service. To extract the animal from the picture can be done with two functions: *GaussianBlur* and *Canny*. With these two functions, we have obtained over 80% accuracy extracting the prevailing and secondary colour of the animal.

To obtain the main words of the voice recorder we process the reconstructed signal with the Google Web Speech API (Shires and Wennborg, 2012), which provides basic Automatic Speech Recognition

(ASR). The ratio of inferred words by ASR varies between 72% and 84% correct words. Pictures and sounds are the easiest way to communicate a LAP, but has a high percentage of error in the feature extraction phase. So that, pictures and recorded sounds are used to endorse the results by the supervisor.

The most important part of the system is the matching process. The matching process decides if an event belongs to a particular animal. Initially, a matching of all features would be the most efficient method. However, the ambiguity of the information provided by users can cause errors in the process. The first approach is to employ a full evaluation algorithm similar to the Linear Discriminant Analysis (LDA) algorithms (Venables and Ripley, 2002).

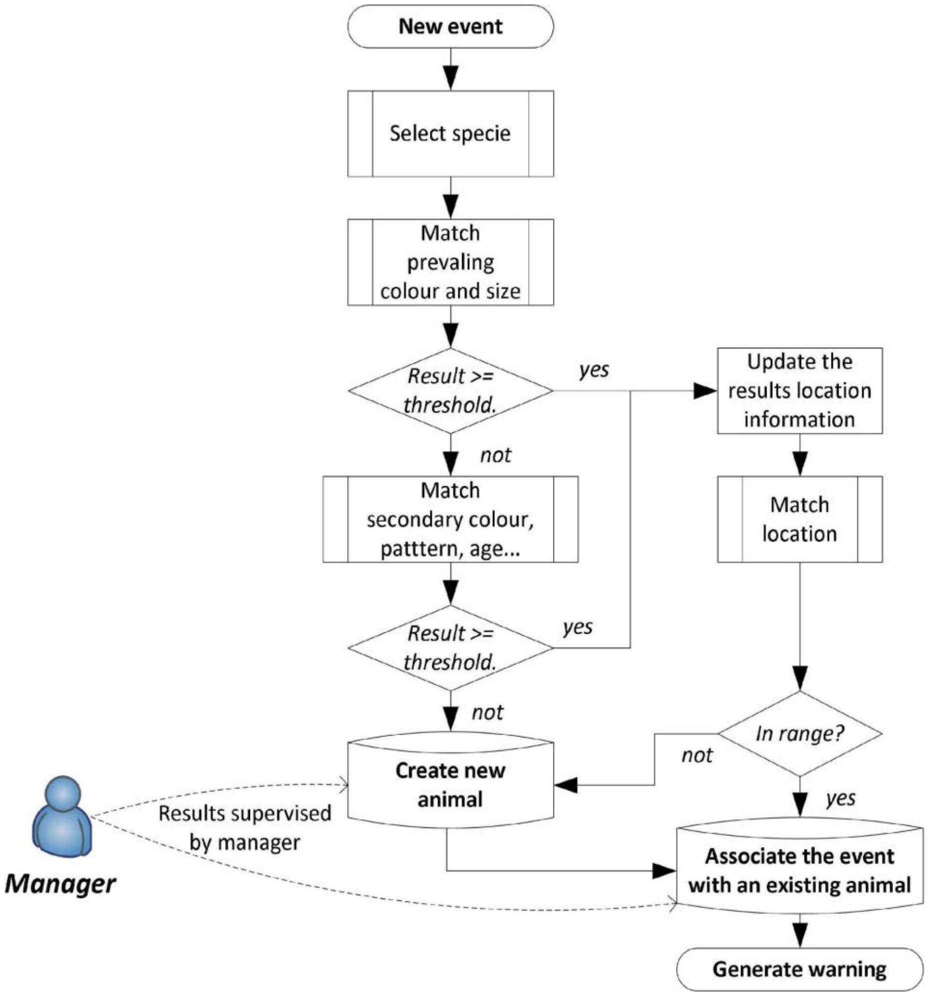

Figure 4. Optimized matching process flowchart.

LDA algorithms are difficult to apply in this case because there are different available features to every animal event and the percentages assigned to each feature can change depending on the animal. For example, if the event is for a cat the secondary colour and pattern will be more decisive than in the case of a dog, where size is more important.

Figure 4 shows the optimized matching flowchart used in the server side. The algorithm uses the main colour and size to determine if an LAP corresponds with a possible animal stored in the database (only animals not rescued are used to this process). If main colour and size don't match, we will use the secondary colour and skin pattern to give a second chance. In both cases, if there is a higher probability than a threshold determined by the manager user, the location match process starts. Location match process uses the average speed of the candidate animal (obtained from the features matching process) to extend the radius of the location area. If animal features and location match, system will offer to associate the event with the animal located and to update the coordinates.

All match processes produce a percentage of matching as a result. If the percentage is greater than that determined b CFy the manager, system will generate automatically the warning to the APS. If the animal features don't match, it will mean that a new animal has been located. In both cases, the manager can directly check the results, features and pictures of animals that have been selected or discarded. This is important because it allows you to adjust the parameters of the OpenCV functions: Canny and GaussianBlur of picture recognition.

4. EXPERIMENTS AND RESULTS

4.1. Client side

To test the system, experiments were carried out on the client and the server side. In the client 25 data inputs have been made using an intelligent mobile phone HTC Wildfire (384 MB RAM; 512 MB ROM and a Qualcomm Processor MSM 7225 528 MHz). The results are shown in Table 2.

Table 2: Basic operating parameters on the client side.

Input method	*Average Time (A.T.) (seconds)*	*Touch Gestures (T.G.) (number of)*	*Information quality (assessment)*
Form	8 sec.	12	High
Virtual draw	5 sec.	10	High
Picture	3 sec.	3	Medium
Sound	5 sec.	3	Medium

One problem is the accuracy of the geographical position of the mobile device. Android contains the "android.location package" to determine the current geo-position. However, the accuracy of the information depends on many factors (such as client configuration or the GPS activation). Fortunately, Android permits to get the accuracy of the location and the last location, so both data is sent to know the reliability of localization.

On the client application, the most important question is to provide the greatest amount of input data methods. Therefore, time stamps are not as important as the usability aspects (like the number of touch gestures) or the quality of the information provided.

4.2. Server side

It is difficult to measure the efficiency of the server because the real improvement is the enlargement of the LAP location, and this rate can be only obtained with the system working in real environment. In the first prototype are several settings that can be analysed from a technological viewpoint. First aspect is the data extraction from pictures. In this case we have tested three methods to extract information from pictures (Table 3): from (Bhagat,. 2005) clustering method and edge detection and from (Laganiere, 2011) the frame and colour recognition based on Canny function.

Table 3: Picture features extraction results.

Method	*Animal specie (dog)*	Main colour *(white)*
Clustering method	56,7%	82,3%
Edge detection	63,6%	82,1%
Canny	48,2%	97,2%

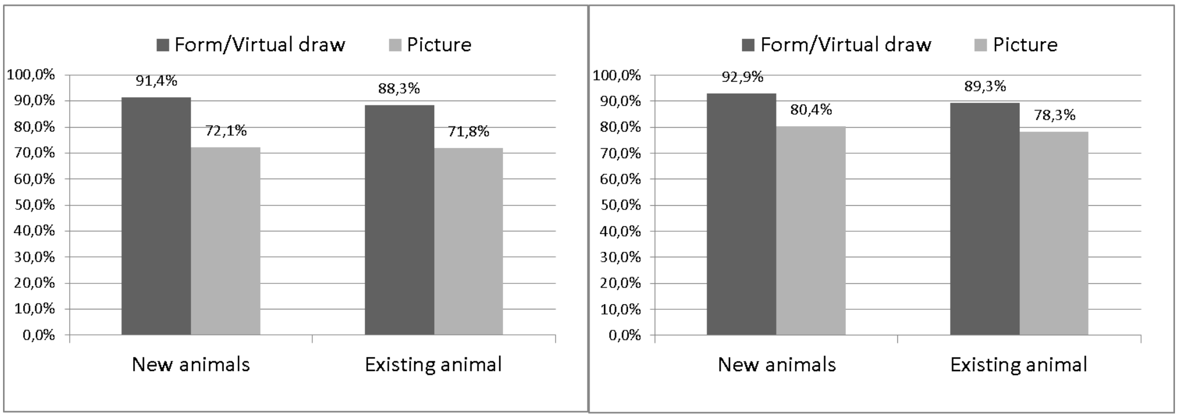

Figure 5. Results of the hits on new animals and existing animals using basic linear method (left) and optimized method (right).

In case of needing further automation of image processing, system should employ a combination of Edge detection and OpenCV based feature extraction. As regards the matching phase, we have compared the basic linear method (based on all the features) with the optimized method. In the comparison, we include the method used to input features. Figure 5 shows the results.

The fact that the optimized method provides a second chance for the secondary characteristics (pattern or secondary colour) increases the hit rate. In addition, there is a difference in the hit rate when to input features a complete method (form or virtual draw) is used.

5. CONCLUSIONS

The automated lost or abandoned management system allows optimizing the pet location. By the provided system it is possible to improve the response time to localize an LAP. Future tests will determine what improvement percentage in the animal rescue is obtained. In the work presented, we observe how some secondary features improve the matching process. Also, system verifies that the updated location process aids to discard more results that using a linear method.

The first test will measure the percentage of successes in the collation within the pets located and the lost pets. Simultaneously it’s necessary to test if the system reduces the time that it takes to locate an animal since the warning occurs compared with current methods used by the APS, and if the system increases animal’s warnings.

System developed suggests a few social challenges. The main one consists of achieving a collation level that permits to increase the lost animal location, as selective messages allow delimiting the search up to the recent places in which the animal has been to. Other challenges refer to avoid duplicate data in databases or even to provide a simple storage method, so as to optimize the abandoned animal adoption depending on the characteristics searched by the adopter.

6. ACKNOWLEDGMENTS

The study described in this paper is a part of the coordinated project COBAMI: Mission-based Hierarchical Control. Education and Science Department, Spanish Government. CICYT: MICINN: DPI2011-28507-C02-01/02 and the project “Real time distributed control systems” of the Support Program for Research and Development 2012 UPV (PAID-06-12)

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