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COCHISE Project: An Augmented Service Dog for Disabled People

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Abstract. Aside from the recent progresses in robotics, autonomous robots are still limited in assisting disabled people. On the contrary, the animal, especially dogs, have demonstrated real skills to support the human being in many everyday life situations, such as rescue (avalanches, earthquakes...), smell detection (drugs, explosives or even cancers), handicap assistance (blind, deaf, motor or cognitive disabled people)... However, each system, the robot or the dog, has its own limitations: a step or a hole can fatally immobilize the machine and a cat may easily distract the animal. Due to the limitations and complementarities between a service dog and an assistive robot, the idea of the Cochise project is to develop a hybrid system animal/robot that will take advantage of both to be more efficient. In the present study, this approach is applied to assist people with motor disabilities. The robot is used to "augment" the service dog by increasing its control from the human being. This machine is a mediator that translates and transmits the dog state to the human user, on one hand, and enables the person to trigger predetermined behaviors of the animal, on the other hand.

Keywords. Service dog, assistive robotics, motor disabilities, human-robot interaction, dog-robot interaction.

Introduction

Many studies have shown that a robotic device may influence the behavior of different animal species. For instance, a "cockroach-robot" can trigger the movement of a flock of cockroaches or other bugs [1, 2, 3, 4]. In addition, robots can be accepted as biological parents in order to take the role of a "mother-robot" that protects her young [5]. It is also possible to control the movements of a rat by directly stimulating of its brain [6].

Another field in robotics tends to replicate animal life for therapeutic purposes. One of the most famous implementations is the PARO robot [7]. This is an interactive fluffy seal that has been successfully used with elderly people in retirement homes and children in hospitals. Attempts have been made to replicate dogs with the objective of substituting assistance dogs with assistive robots, in order to facilitate human-robot

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interaction [8, 9, 10, 11], in particular with the AIBO robot from Sony [12, 13, 14]. Even though more children consider a live dog, as compared to a robot-dog (AIBO), as having physical essences and emotions, many of them interact and conceptualize AIBO like a real dog [15]. The learning motivation is also higher if preschool children are interacting with AIBO than a stuffed dog [16]. Children with autism are more engaged verbally and physically when they interact with a robotic dog (AIBO) than a toy dog (KASHA) [17].

Despite being inspired by animals, the behavior of the dog-like robots is still very limited and therefore difficultly accepted as companions. At present, the best approach to implement this concept is to design robots which are more task specific [18]. This reality suggests that it is premature to use an entire autonomous device to substitute a pet. On the contrary, a hybrid system that takes advantage of the dog's flexibility/adaptability and the robot's reliability/consistency could be the perfect way to assist people in a determined task.

At the 12th International Association of Human - Animal Interaction Organizations (IAHAIO 2010), a Japanese team presented a robot that played with an assistance dog, by throwing a ball to the animal and having it bring it back. However, in spite of the numerous studies on the human-dog relationships, none of them applies on the "augmented assistance dogs" through a robotic device.

1. Methodology Used

Cochise is a multidisciplinary project merging competencies from assistance dog handlers, roboticists and experts in human-machine interfaces and computational architectures. The methodological approach consists in taking advantage of the multitalented skills of the dog (affective relationship, sensorial capabilities, motor skills...) and using the robot to correct the intrinsic unpredictability of the animal's behavior. In practice, the robot has two specific roles, which are:

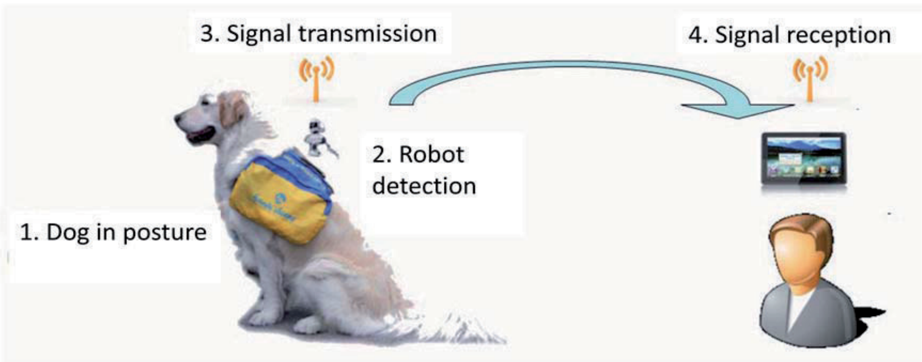
- To provide an alarm signal to the human being (the master and/or a third party) if the dog faces a determined problem.
- To preserve dog obedience in an autonomous way or by a remote control from the human user.

In order to find a solution for the alarm and obedience problems, it is necessary to list the specific behaviors of the dog. This list, called an ethogram, enables us to identify some identifiable states of the animal's behavior, such as barking, lying down on its back or on its side, sitting down, running around, dropping its head... Each specific behavior is an alarm signal that must be correctly interpreted in order to ensure a proper response. A nomenclature of the technical solutions related to each dog signal is laid down in such a way that a sensorial device matches a characteristic behavioral parameter and an appropriate alarm signal. Other signals can come from physiological monitoring of the animal or an analysis of the environment by a camera or a GPS position, for instance, and must be transformed into discriminable information that is broadcasted to the human user.

2. *Ongoing Work and Results*

2.1. The Alarm Signal

Triggering an alarm from the robot (carried by the dog) consists in sending a signal to the master or a third party. A signal may be sent to the dog's owner when the dog violates an instruction or does not follow the correct behavior. A signal will be transmitted to a third party, for example, if the animal fails its mission to watch its master and keep him/her inside a limited area. The alarm is broadcasted through the robot by "yapping" or other such specific behavior. The robot ensures the dog monitoring by measuring and analyzing different parameters with diverse sensors (Fig. 1).

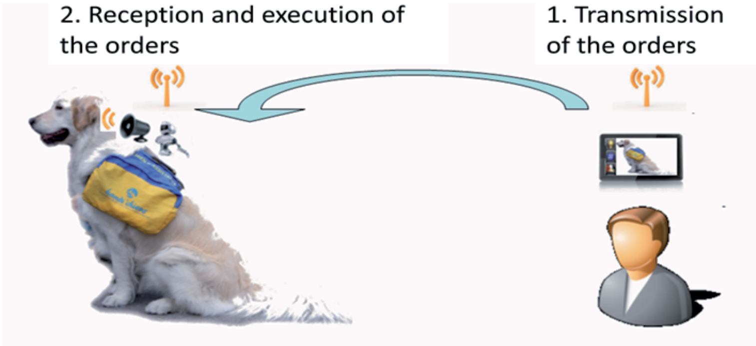


Alarm implementation		
Types of signal	**Types of technology**	**Data processing & interpretation**
Dog barking Posture : sit, lie …	Microphone, Accelerometer, Gyroscope, Contacts, Pressure sensors	Form recognition, Signal processing, Multi-sensor fusion
Environment	GPS, Camera, IR barrier	Cartography
Interface	Computer, Cell phone, Tablet, Specialized peripherals…	Customized multimodal restitution

Figure 1. The alarm implementation.

2.2. The Obedience Control

Once the alarm is received, the human being (master or third party) must be able to remote control the dog through the robot, or to request the robot to execute a specific task. In this latest case, the robot has to work autonomously. The machine becomes a substitute of the master, by giving a direct order to the dog and rewarding or punishing it whether or not the animal behaves in the desired manner. The obedience control requires the implementation of an electromechanical device that stimulates one or another dog sense (Fig. 2).



Obedience implementation		
Types of signal for the dog	**Types of technology**	**Functionalities**
Hearing	Loudspeakers	Display of remote or prerecorded voices, ultra-sounds
Smell	Servovalves	Control of duration and/or intensity
Touch	Vibrators, Actuators (compression, light nociceptive stimulation, caress), Resistance (heat)	Control of force, velocity and intensity
Taste	Relays, Motors	Kibbles delivering
Sight	Laser pointer, Pico projectors	Visual steering control

Figure 2. The Obedience Implementation.

2.3. Technical Implementation

The activities detection is the first tool of a set that will be experimented. It will allow the discrimination and classification of four types of dog behaviors (walk, run, lay and sit down) to trigger the appropriate answer through the robot. Other tools that will be implemented are GPS tracking, video streaming, and giving orders by remote control. Due to its numerous advantages, a smartphone is used for the communication between the animal and the owner. It is a small and powerful embedded processor that has many built-in devices such as GPS, camera, speaker, sensors, and communication capacities GSM, Bluetooth, Wi-Fi… For instance, in order to detect the dog activity, the following three phone sensors are used: 3-axis accelerometer, 3-axis gyroscope, and 3-axis magnetometer.

Figure 3. The dog with a smartphone on its back.

The smartphone is placed on the dog's back. The orientation of the sensors is shown in Figure 3: Y-axis to the dog's head, X-axis to its right side and Z-axis in the upright position.

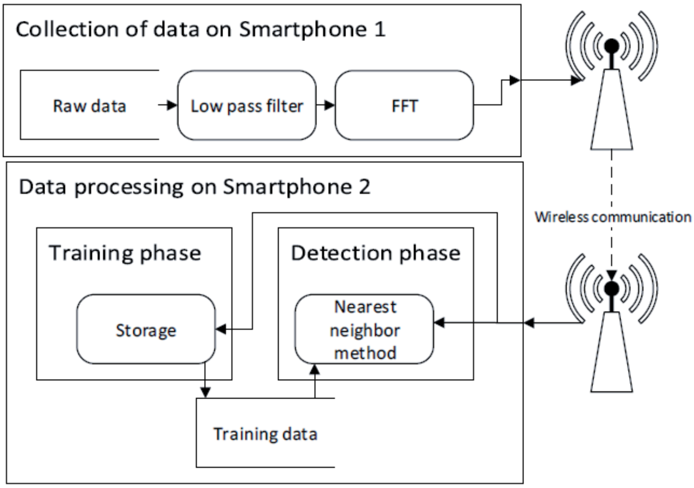


Figure 4. Data flowchart.

Figure 4 describes the data flowchart of the activity detection. In order to extract the periodicity of the movement, data are filtered with a low pass filter and a Fast Fourier Transform (FFT) is achieved. Then, the signal amplitude and frequency are extracted. This processing is done locally in real time by the smartphone 1, on the dog's back. Every 2 seconds the data are wirelessly sent to the smartphone 2, in the dog's owner hand, which executes the detection. The same technology will be used to transmit an order from the disabled person to the animal.

3. Economical and Societal Impact

The animal is a great companion for the human being. When the human-animal relationship is really strong, the animal becomes a partner that completes services for its master. In particular, the human being takes advantage of the dog's skills in the domestication context. The service dogs for the assistance of disabled people represents a high demand, which increases constantly in developed countries (more than 1200 assistance dogs are already operational in the French territory only).

Optimizing the dog working performance and improving the communication of the master-dog couple, thanks to an assistive robotic device, is an important societal issue that involves a potential of thousands of dogs. Extending the scope of working dog actions is a second relevant issue regarding the human, social, economical and technical consequences.

Among working dogs, assistance dogs, who are in charge of helping handicapped people in their everyday life activities and facilitating their social integration, are the perfect candidate for pilot studies involving a "mediator robot" and to open up other potential applications.

4. Conclusions

The Cochise project has two main objectives: improving the knowledge of the animal-machine interactions, on one hand, and developing a prototype that can soon be available on the market, on the other hand. In practice, this study aims to improve the collaboration between the human being and the dog, in an assistive framework. The technological exploitation of assistance dogs represents a societal issue due to the fact that a robot, which is capable of working in synergy with an educated dog, may simplify many issues related to rescue, working dog situations or, just, companion dogs. The overall benefit of this project is to allow the increase of the human presence alongside the animal, despite a possible remote position of the handicapped person.

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