The PoulBot: a mobile robot for ethological studies on domestic chickens

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Abstract. This paper presents the "Mixed Societies of Robots and Vertebrates" project that is carried out by the Mobile Robotics group at EPFL, Switzerland in collaboration with the Unité d'Ecologie Sociale at ULB, Belgium. The idea of the project is to study behavior in young chicks of the domestic chicken (Gallus gallus domesticus) by using mobile robots able to interact with animals and accepted as members of an animal group. In contrast to other studies where relatively simple robotic devices are used to test specific biological hypotheses, we aim to design a multipurpose robot that will allow ethologists to study more sophisticated phenomena by providing a wide range of sensors and sufficient computational power. In this paper we present a PoulBot robot and give an example of the ethological experiment, where it is used to study the social aggregation in chick groups.

1 INTRODUCTION

One of the long-standing interests in behavioral studies is to understand relationships between stimulus and response. To study this mechanism researchers often use specially designed mock-ups whose behavior can be controlled in details to monitor a response of the animals under test. Being originally quite simple, nowadays such artificial models become sophisticated robotic devices thanks to availability of low-cost miniaturized computer chips, motors and sensors. This allows to test hypotheses on animal behavior that were to tricky to work with before [5]. Recently robots were used to test ideas about the mate selection in bowerbirds [7] and in tungara frogs [9], to study the male territorial instinct in dart-poison frogs [6], the nest mate recognition in brush turkeys [1], the predator avoidance by ground squirrels [8] and the rats cognitive ability [4]. In most of these studies robots were built to test only one or very few specific behaviors and thus endowed with a limited number of sensors and computational power; the majority of them had to be remotely controlled during the whole experiment.

The goal of our work is to develop a more advanced mobile robot, equipped with a wide range of sensors (cameras, microphones, proximity sensors, etc.) and a sufficient computational power, which will allow ethologists to study more sophisticated phenomena. This robot will be used to address such scientific questions as link between individual and collective behavior, sound communication, role of personality in collective decision making and pattern recognition in the domestic chicken (Gallus gallus domesticus). We also model the collective movement behavior. The individual based models that are usually used to model birds flocks are not generally applicable for small groups, since they consider all the animals to be identical and groups being large. We, on the contrary, aim to research how individual features and leadership influence the collective movement.

Methodologically our project continues the European project Leurre, where mobile microrobots were designed to study and control the social aggregation in cockroaches [2]. Another example of a project dealing with domesticated birds-robot interaction is the Robot Sheepdog Project where a mobile robot was designed to shepherd a flock of ducks and to lead them to a specified position by scaring them [10].

In this paper we present the current progress in the project: the PoulBot robot design and control system, and experiments on the social aggregation in chick groups that we are currently conducting.

(a) The design of the PoulBot robot. The plexiglas bumper protects chicks fingers from been stuck in the robot's tracks

(b) The current version of the robot. Black stripes pattern serves to improve the imprinting efficiency

Figure 1: The PoulBot design and its current prototype

2 THE POULBOT ROBOT

The PoulBot (Figure 1) is a track-type mobile robot that has a size of an adult chicken. It is equipped with infrared proximity sensors around the robot, a gyroscope, an accelerometer, a speaker, provides a Bluetooth connectivity and an energy autonomy up to three hours. The robot has an external vision system to track chicks displacement using the overhead camera. To introduce the robot into the animal group we use the filial imprinting mechanism; shortly after hatching we present the moving and vocalizing PoulBot to chicks, afterwards chicks are attracted by the robot and demonstrate the following behavior. Because variations in size, shape and color are well tolerated for imprinting [3], it is not necessary for the robot to look like a hen.

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The large number of onboard sensors implies that a control system has to be relatively complex; since the main interest and concern of biological researchers lie in proper setting and conducting of animal experiments and not in operating an intricate control interface, our goal is to hide this complexity and to provide a robust and easy to use control system. We use a behavior based controller: the PoulBot is equipped with a number of basic behaviors such as *obstacle avoidance*, *holes avoidance*, *wall following*, *random walking*, *goal following*, etc.; these behaviors can be combined together to form higher level behaviors needed for the current experiments.

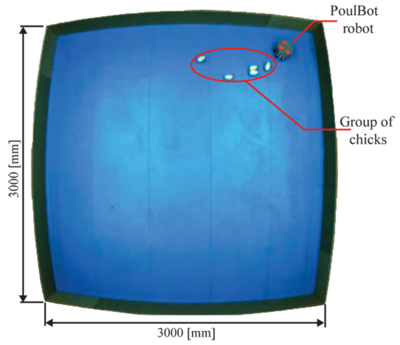

Figure 2: The experimental arena with the PoulBot robot and a group of chicks

3 EXPERIMENTS

At the moment we run indoor experiments at the Brussels University to study the principles of social aggregation in chick groups. The experimental arena is a flat square 3 by 3 meters surrounded by a wooden wall of 30 cm height (Figure 2). The floor is painted in a blue color to simplify the tracking task.

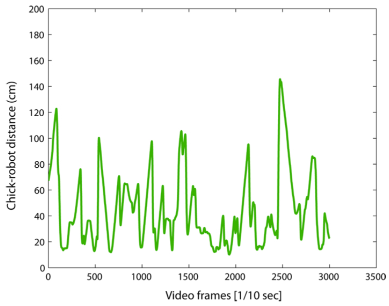

Figure 3: The chick-robot distance. The oscillating character of the data indicates the elastic interaction type of the following dynamics between the chick and the robot

Tests are begun by placing a group of chicks (from five to ten individuals) on the arena, where the robot executes a random walking. The chicks are imprinted on the robot, but they are also imprinted on their siblings. We want to study how a chick behavior depends on different cues related to the behavior of the robots and other chicks. We also study the notion of leadership in collective decision making. Chicks have to decide how to deal with their inter-attraction and their attraction towards the surrogate hen. The Figure 3 shows a sample chick-robot distance from one of the experiments; it demonstrates an elastic interaction dynamics of the chick when it follows the robot, but the exact mathematical model is to be formulated.

4 CONCLUSION

In this paper, we have presented current progress on the PoulBot project: we have described the hardware and software of the robot to interact with chicks and have given an example of experiments that we run.

We aim at building artificial systems capable of perceiving specific animal behaviour and to be capable of interacting by appropriate behavioral responses. On the one hand the robots have to reach a sufficient level of cognition for being capable of understanding what animals are doing. On the other hand they have to be capable of emitting appropriate behavioral responses to the animals. These responses are based on known or to be discovered animal cognitive capabilities and behaviors. In other terms the artificial and natural systems has to present some form of mutual relationship, albeit simple at the present stage. Our aim is to build tools that will be used in studies of collective animal behavior that extend classical luring methods. The design of a robotic system is an iterative process closely coupled with a research work on collective animal behavior. Once we have such hybrid systems, we can speculate on the possibility of using the characteristics of each one that are different. The artificial systems could make use of animal cognitive or behavioral capabilities to get information that are inaccessible to it directly by its sensorial capabilities. The natural system could use the capabilities of the artificial system that are foreign to itself like for instance long range communication. This research line is limited by what can be done in artificial intelligence and what we know about animal cognition and behavior. This mirror effect should shed light on their specific limitations and could show were research efforts are necessary in terms of AI and animal intelligence understanding.

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