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A NEW TRACKING SYSTEM TO STUDY THE BEHAVIOUR OF SPECIES

David Sarriá [1], Joaquín del Río [1], Antoni Mànuel [1], Xavier Roset [1], Jacopo Aguzzi [2], Francesc Sardà [2]

[1] Centre Tecnològic, SARTI, Vilanova i la Geltrú, Spain, david.sarria@upc.edu
[2] Institut de Ciències del Mar. CSIC, Barcelona, Spain, jaguzzi@cmima.csic.es

Abstract – A tracking system with RFID technology has been developed to measure the activity and behaviour of species in laboratory. It consists of different controllers which handle different RFID antennas. The controllers send the data received from its antennas to a host computer that computes the tracking of the different individuals. The system has a tracking resolution of centimetres and was specifically designed to respond in hostile environments and to allow an easy configuration and expansion.

Keywords: RFID, microcontroller, USB communication

1. INTRODUCTION

The system described in this paper has been developed for the CSIC marine biologists group to study and measure the rhythmical burrow emergence of the Norway lobster. The Norway lobster, *Nephrops norvegicus (L.)*, is a decapod crustacean inhabiting complex burrow systems in the muddy continental shelves and slopes of Atlantic and Mediterranean Europe. This specie is fished intensively in the Mediterranean by trawl tow gears. Since these crustaceans are only captured when they are outside the burrows and emergence is apparently modulated by demographic factors (i.e. age, size and sex of individuals), the estimations of the biomass population of this important fishing resource are difficult without laboratory studies on its behaviour.

On the other hand, the population and activity of marine species has acquired in recent years a great interest to control fishing activities and to allow sustainable exploitation. So there is an increasing need for the study of species with an appropriate equipment in laboratory, where is easy to recreate different conditions and to compare results obtained applying different modulation variables, like photoperiod and intensity light, food presence, isolation or coexistence in group.

Basically the main difficulty of such a system is to measure the position of individuals without contact to avoid changing their behaviour. Some previous work can meet these goals [1].

Infrared technology can allow detecting the step of the animal in a determinate zone without altering their behaviour to those animals non-sensitive to infrared wavelengths. Adding more detection areas would improve the tracking resolution. However this solution only permits to detect if the specie has passed through the detection area without identifying it.

With computer vision technologies is possible to track different individuals at the same time, but complicate algorithms are required and adapted to the specie. Some factors like illumination and position of cameras make difficult and expensive this solution. In particular, for marine species, the light reflected in water prevents a correct vision, so in this case, polarisers and infrared cameras must to be used to avoid reflections and to capture images in darkness. The tracking algorithm should be adjusted according to cameras position, illumination, individuals and the zone under analysis. All of these reasons make a more complicated and expensive design with high costs in its ongoing maintenance and configuration by trained personnel.

The above solutions were studied in a previous work [2] and were applied in field for the study of isolated individuals.

This paper aims to present a new technology for the biological community that allows the study of species in laboratory with the particularity that the system is able to indentify each individual, so is possible a tracking of every specie and to study the behaviour of them in coexistence. The technology used is adaptable to many species and environments reducing the cost, maintenance and increasing the quality of data (frequency measurement and tracking accuracy) to study the behaviour of species.

2. DESIGN

The system structure is shown in Fig. 1. It is formed by a set of replicas of a design called RFID controller which handle different antennas (RFID readers) that are positioned under the aquarium. The RFID readers have an UART interface that permits to communicate with the controller who queries the presence of transponders in the coverage field of the antenna.

The developed RFID controller is governed by a microcontroller that manages up to seven RFID readers multiplexing the UART lines of the uC to the readers.

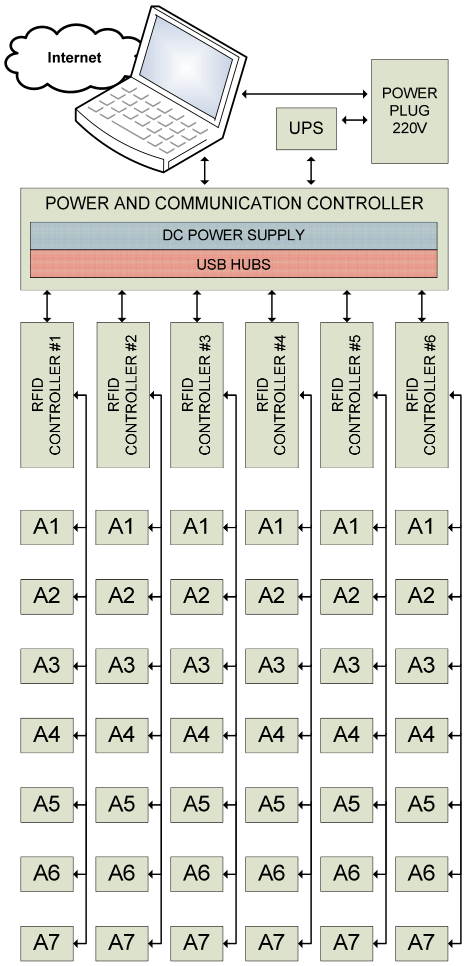

Fig. 1 Tracking system structure

The controller sweeps all the readers in sequence in order to know the status of readers and the presence of tags in all of them. The microcontroller has a time routine to connect to the next reader if the current does not respond. This routine permits to continue the normal operation of the controller without blocking, if the reader fails is discarded automatically and also if it is disconnected. If a new reader is connected to one of the free ports, the microcontroller recognizes the situation and deal with it.

All the data received from the readers is stored in the microcontroller memory. When the sweep end (data acquisition of all readers) all the data is sent to the computer using the USB interface, the process is repeated scanning again the readers until the computer notifies to stop this task.

All controllers work in parallel, so with six of them we can control up to 42 readers or antennas (Fig. 1). The reason to design a small controller (able to control few antennas) is to built a system with a distributed topology, this improves the flexibility of assembly and permits to expand the system easily, also if a module is damaged due to the environmental conditions of the system (presence of water) is more easier to repair and the cost is lower than a complete system.

We have developed a second system that contains USB hubs and a DC power supply. This system is responsible to supply power to all antennas; this is because each antenna needs about 150mA at 5V when a transponder (tag) is read. If all antennas of the same controller detect a transponder, the consumption of the USB specification will exceed [3]. So the antennas aren't fed with the USB power lines but from an external power supply (Fig. 1). For this reason the cable that connects the controller to the power and communication controller is a special cable (Ethernet cable) with the USB lines and the external power line.

Several USB hubs are inside the power and communication controller. These hubs are powered with the DC power supply and interconnected in cascade. Only one port is needed to be connected to the central computer to control the system (controllers and readers), regardless of how many readers are connected. The system is easily expandable by connecting new RFID controllers to the USB hubs, the maximum number of devices is determined by the USB specification (127 devices per port), for this design it means up to 889 antennas.

On the other hand every individual carries a small passive transponder (no battery, 2.5cm diameter) which is powered by the field induced by the readers. Each transponder transmits its UID when the reader requests it. The position of every individual is directly extracted from the location of the reader which is known in the assembly.

Fig. 2 Assembled tracking system in the aquarium

All this implementation was assembled in an aquarium of 150x70cm. In this scenario, to track the movement of several lobsters, the readers are positioned in strategic zones below the aquarium (Fig. 2).

Finally a LabVIEW application controls the system, collect the data from readers and perform the tracking of species. The application stores in files the position of every specie when the antenna detects its transpoder. A previous calibration was required to measure the exact position of the antennas in the aquarium (x/y coordinates) to present also the displacement in real words of the specie.

A remote server application permits to control and to visualize the experiments and the tracking through Internet and by ftp server the experiments can be downloaded without stopping the current experiment, accelerating the study of data; every experiment can last several weeks.

3. TECHNICAL RESULTS

As it is known, RF signals have a great attenuation under water. A comparative study was needed to ascertain the level of coverage through different readers: 125 kHz to 13.56 MHz and different types and sizes of transponders.

At the end, although at a 125 kHz we got very good results of coverage; we decided to choose a reader with an operating frequency of 13.56 MHz to improve the resolution and accuracy of localization (the antenna and tag size decreases if frequency increases) and because the distance transponder-antenna meet our specifications (below 4cm). So this technology is able to work in water but only with species that walk above the floor, if the distance transponder antenna was great, we would have to increase the size of the transponder to maintain this operating frequency.

We made several tests and with a round transponder of 2.5cm diameter we cover our specification minimum criteria of 4cm (Table 1).

Table 1. Coverage distance Vs. different transponders

Diameter [cm]	Heigh [cm]	Frequency [MHz]	Weight [g]	Distance [cm]
3.45	0.6828	13.56	3.578	8
3	0.076	13.56	0.646	6
2.5	0.1	13.56	0.762	5.5
2	0.11	13.56	0.516	4.5
1.7	0.335	13.56	0.604	3

4. BIOLOGICAL RESULTS

For the moment three experiments have been done up to the present and processed data is being analyzed by biologists. These investigators are finding enlightening results on the emergence activity rhythms of the Norway lobster for their research. Some results of the preliminary trials are presented in Figure 3, these graphs shown the tracking and displacement of three lobsters in an experiment of seven days.

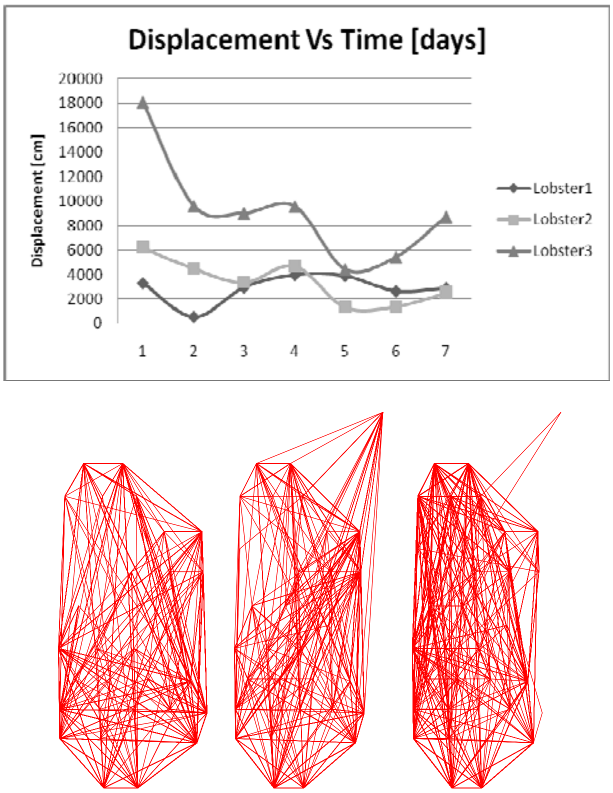

Fig. 3 Displacement Vs. Time and tracking

With the results presented is clear that more days are needed to study if exists an activity pattern, although a similar locomotor activity is detected between two lobsters (lobster two and three), these lobsters lived close in the aquarium during the experiment. On the other hand lobsters decrease their locomotor activity at the second-third day of experiment (adaptability in the new habitat).

Now biologists are studying more data such time of activity, activity differences between males and females, isolation and coexistence in group and so on. In next experiments some environmental variables will be applied to determinate their influence on the modulation of this specie.

5. CONCLUSIONS

A tracking system with RFID technology has been developed. This system has a tracking resolution of centimetres, its design has a distributed topology and offers a great flexibility and it is easily expandable; only is needed to connect to the USB ports the controllers and antennas necessary. Programming the computer BIOS to reboot in case of power failure may be interesting and appropriate as well as use an uninterruptible power supply to give stability to this type of system that works autonomously for several weeks.

It is important to indicate that the system is not closed to study particular specie but also all kind of species that move along the ground. This design solves and offers an expandable and flexible system with a nonexistent technology in the market.

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