

Wild animal tracking by PHS (Personal Handy phone System)

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Abstract

Miniaturization and integration of portable devices have been achieved so remarkably day by day that wearable computing is being realized. It seems that vast amounts of wearable information devices will be attached not only to human beings but also to nature environments and artifacts and they will be connected with intelligent network in the future. We attached PHS location devices to urban animals such as Raccoon Dogs and Crows and tracked them. In the Crow experiments, in which lighter devices than 30g were required, we realized the Crow tracking with PHS location devices, which weighed about 28 g.

1. Introduction

The volume and mass of an information device must be zero ultimately. Microsystem technologies have been developed in order to achieve this ultimate goal from such various fields as electricity mechanics, physics, and chemistry and it seems the development will be continued. It has been possible to detect signals generated by an environment or living body and make a judge and process because of the rapid progresses of such technologies as microsensors, microactuators, wireless, and Internet communication these days. The category of information devices has been changing from Mobile into Wearable with such technological progresses. A cellular phone, which is always in a breast pocket, is the typical example. It is possible for wearable devices to apply not only to human environments but also to artificial environments, wildlife environments, and nature environments, by attaching the devices to artifacts and things of the nature. We proposed such an information device attached to various things as Nature Interfacer^[1]

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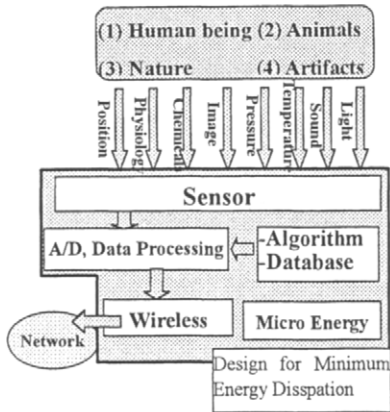


Fig.1.1 Architecture of Nature Interfacer

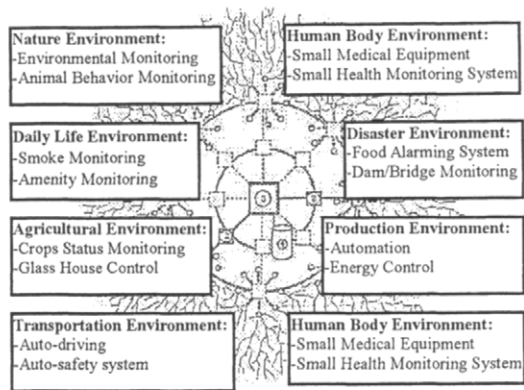


Fig.1.2 Concept of Wearable Information Network

Its architecture is shown in FIG1.1. First, Nature Interfacer detects such analog signals by sensors as light, sound, temperature, pressure, picture images, chemical substances, physiological information, and position, all of which are sent by human, wild lives, nature, or artifacts. Second, a CPU converts the analog signals into digital data and the data are recognized and processed based on database. Last, the data are transmitted to networks wirelessly. By using the public or wide area network, the remote collection and control of various kinds of environment information are available, which is what we call WIN^{[2][3]} (Wearable Information Network) [Fig. 1.2].

The examples of WIN application studied these days are as follows:

- Environment monitoring and Animal behavior monitoring in Nature environments.
- Smoke monitoring and Amenity monitoring in Daily life environments.
- Automation and Energy control in Production environments.
- Small medical equipment and Small health monitoring system in Human body environments.
- Auto-driving and Auto-safety system in Transportation environments.
- Crops status monitoring and Glass house control in Agricultural environments.
- Flood alarming system and Dam/bridge monitoring in Disaster environments.

2. Wild animal tracking by PHS

Animal behavior monitoring, which part of nature environment monitoring, was done in order to find the wearable information network. Raccoon Dogs and Jungle Crows were tracked in the following two experiments.



Fig.2.1 Vinyl house damaged by raccoon dogs
(The University Farm, Tanashi City, Tokyo)

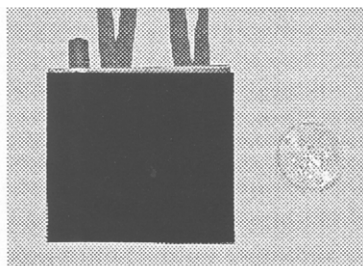


Fig.2.2 PHS location device attached to
the raccoon dogs (size[mm]:67x67x11).

2.1 Raccoon dogs tracking by PHS

2.1.1. Introduction

Wild Raccoon Dogs, *Nyctereutes procyonoidides*, are living in such urban areas as Tanashi City, Tama City in Tokyo, Yokohama City, Kamakura City in Kanagawa prefecture. They often damage farm products, plastic greenhouses and public electrical cords. They are sometimes hit by cars and die on public roads [Fig2.1]. The number of such incidents is increasing day by day. Though they cause such problems, many aspects of their ecology, such as the daily movements and habitat use has remained unknown. There were some tracking experiments in the past by attaching a telemetry device on a raccoon and chasing its radio wave with antennae. But such experiments required a lot of time and manpower, and telemetry tracking is not a best way in an urban area where many obstacles such as buildings and so can interfere with radio waves. In this experiment, raccoon dogs were tracked by the PHS (Personal Handy-phone System), which has human position-locating service. The raccoon dogs tracked in this experiment were living wildly in the University Farm and Forest in Tanashi City, Tokyo.

2.1.2 Preliminary investigation

Before tracking the wild raccoon dogs, the location accuracy of the position tracking system was investigated by walking randomly around the University Farm where raccoons were likely to be seen. The results showed an average error range of less than 100-200 meters. This means that we can recognize by the PHS whether raccoons are inside the Farm or not, and if inside, whether they are in the center of the Farm, northern end, southern end, eastern end, or western end.

2.1.3 Raccoon dogs tracking by PHS

One male raccoon dog and one female raccoon were caught in the University

Table2.1
Results of the two raccoon dogs experiment

	Life of battery	Number of data	Number of the valid data	Frequency of the valid data
The male	20 days	676	265	39.2 %
The female	12 days	458	458	59.4 %

Forest and PHS location devices produced by Alps Electric, which weighed about 58g, were attached to the two raccoon dogs [Fig2.2]. The PHS was in a vinyl bag for waterproofing. The access frequency for getting location data from the PHS was every thirty minutes between 3:00 pm and 8:00 am, for raccoon dogs are nocturnal animals.

2.1.4 Results

The results of the tracking raccoon dogs with PHS experiment are shown in Table2.1. The number of the valid data means how many times the tracking data sent from the PHS attached to the raccoon dog was in the PHS service area (valid area). Except for the valid location, the PHS was outside the PHS service area (invalid area), and the tracking data were not sent. The frequency of the valid data means the frequency when the raccoon was in the valid area. The result showed that the male raccoon dog was more often in the invalid area than female. The number of the access to the male PHS is smaller than that of the female one, hence the life of battery for the male PHS is thought to be longer than that of the female one. It was shown that the raccoon dogs acted during the night and had its place to sleep every day and its home range was inside the Farm and the Forest.

2.2 Crow tracking by PHS

2.2.1 Introduction

Jungle Crows, *Corvus macrorhynchos*, one of urban birds in Japan, are increasing in number and causing such problems as eating garbage. And the problem is so serious that the Government of Japan has considered in the Diet^[4]. Crows flying around residential areas and downtown areas are seen everyday. As to the ecology of crows in central Tokyo, their number and their active areas are roughly known. But their daily movements are not well known. It is one of the problems, which prevented us from tracking the crows, that it was very difficult to radio-track crows from the ground. In order to grasp their activities, we developed a new method using position-tracking using PHS. Network area of PHS corresponds to living area of crows and crows were tracked successfully by PHS in 1999.Sep^[5]. But there remained a device's weight problem.

Table2.2**Specifications of P-doco? and remodeled device.**

	<i>P-doco?</i>	<i>Remodeled device</i>
Size [mm]	69.1x41.4x17.4	63.1x39.0x14.0
Case [g]	19.4	8.0
Battery [g]	15.25	8.0
Others [g]	7.75	12.1
Gross weight	42.4 g	28.1 g

**Fig2.3. Crow with PHS (in the circle)**

In general, it is said that the weight of a device attached to birds should be designed under 4-5% of their body weight ^[6]. As the body weight of a Jungle Crow is about 500g-700g, the required weight is 20g-35g. Though every effort was made, the PHS device attached to the crow weighed about 44g.

2.2.2 Devices attached to Crows

The NTT DoCoMo, Inc.'s PHS location device called "P-doco? ", which originally weighed 42.4g, was remodeled to lighten. Its case was thinned down and batteries were changed to two button-shaped batteries (CR2430, 150mAh by Fujitsu). The details of the lightened device are shown in TABLE 2.2. The remodeled device was authorized by the Ministry of Posts and Telecommunications.

2.2.3 Outline of the crow experiment

Batteries perform worse under low temperature so that the experiment was done from Mid-April '00 when it's getting warmer.

Ten Jungle Crows were captured in cooperation with Ueno Zoological Park in a trapped pen and the PHS device was attached to each of them. The average weight of the crows in this experiment was 638g and so the required weight of the device (less than 5% of a crow weight) was 31.9g. The devices, which weighed 28.1g and was used in this experiment, met the demand. Toyobo's Toyobo Dyneema^{R[7]}, which is made from polyethylene, was strong, light, and durable enough to use as the string to attach the device to the crow. Though the device was attached to crow's breast in the last experiment because the device was a little bit large, the new smaller device was attached to crow s back like a back-sack [Fig2.3]. The access frequency for getting location data from the PHS was every thirty minutes between 3:30 am and 7:30 pm in cooperation with the DoCoMo Support, Inc.

2.2.4 Results

As a result, for example, one crow went around the central parts of Tokyo, such as Ginza or Roppongi from Ueno Zoological Park and one crow went up to a suburban area in Arakawa riverbed. The place where crows act in daytime turned out to be not only one place. And as to the Ueno Zoological Park it was shown that some crows used the Park as their roost and others used as their foraging area.

3. Conclusion

The conclusions based on the experiments of raccoon dogs and crows were as follows:

- [1] One example of Animal behavior monitoring in the Wearable Information Network was shown.
- [2] It was shown that PHS, originally for human use, was also available for urban animal tracking even if they are flying birds.
- [3] Crow tracking with 28g PHS device was successfully achieved and the weight problem of the previous experiment was solved.

4. What's next?

We are trying to lighten the device and lengthen the battery life, and its application to other wild animal is considered. In addition to the location information of animals, we have it in view that we will construct the wearable environment information system in which various information of ecology is detected by Nature interfacers.

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