Application of Bioradiolocation for Estimation of the Laboratory Animals' Movement Activity

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Abstract— A method for estimation of the laboratory animals' movement activity by means of bioradar is proposed. The method could be used in time of zoo-psychological and pharmacological experiments. The experimental results for different states for the animal are presented. Specific features of frequency spectrums for these states are analyzed.

1. INTRODUCTION

Radiolocation of biological objects named as bioradiolocation is an intensively developing area of bio-medical engineering. There are some important medical tasks which could be applications fields of radiolocation, among them are disaster medicine (searching of survivals under debris and rubbles of buildings), monitoring of breath and heart beating parameters for burned patients (it would cut down the number of used contact censors and thus decrease the risk of infection inoculation into burning wounds), sleep apnea diagnostics, monitoring of breath and heart beating parameters for sick persons, which are the carriers of extra-hazardous infections (it would decrease the risk of medical staff infection), and etc [1, 2].

Besides the over listed fields of application there is an interest in usage of bioradiolocation for remote diagnostics of rats and other laboratory animals by estimation of their moving activity in time of zoo-psychological and pharmacological experiments.

At present, invasive methods of physiological parameters determination are used during testing of some medicine and poisonous substances on laboratory animals. Their moving activity used to be estimated visually by researcher. It could be pointed another method that is currently in use for animals' behavior reaction analysis. Specially designed video tracking system such as Ethovision [3] can be applied to decrease a workload of the researcher and create automatic approach to estimation of moving activity. The main disadvantage of this type of systems is necessity to use sophisticated software and some restriction on long time recording with duration more than several hours because of data storage capacity limitations. So, that is why in most cases estimation of rats' moving activity is carried out by researcher visually [4], which might cause in the quality of obtained information.

Doppler radar has advantage of direct measurements of animal's moving parameters. It can be used for creation of a fully automatic moving activity integral estimation procedure. In this case the size of data is so small comparing to the video file that it would allow to record data continuously during several days or more. Moreover in condition of creation special recognition algorithms of radar signals that were reflected from animal, it would be possible to discriminate different types of its movements (horizontal and vertical activities, grooming, steady state). In that case bioradiolocation can be also applied to data analysis of the open field experiments.

Several experiments were carried out to investigate possibilities of laboratory animals' movement estimation by means of radar. These experiments and their results are given below.

2. EXPERIMENTAL INSTALLATION

Multi-frequency radar with quadrature receiver designed at the Remote Sensing Laboratory was used in experiments with laboratory rats. The radar had following technical characteristics:

Number of frequencies	16
Sampling frequency	62.5 Hz
Operating frequency band	3.6–4.0 GHz
Distance space resolution	0.5 m
Recording signals band	0.03–5 Hz
Dynamic range of the recording signals	60 dB
Dimensions of antennas block	$150 \times 370 \times 370$ mm

This radar was created for distant monitoring of movement activity, breathing and pulse of human. But it could be also used for tracking movement of small laboratory animals. The main problem is that the rat is just a little bit bigger than space resolution ability of the device. And since the bioradar was created for human's observation, the heartbeat frequency band of rats (6–7.5 Hz [5]) is higher than recording signal band.

Sketch of the experimental set up for estimation of animal's movement activity by means of radar is given on Figure 1. During experiment the animal was placed into a box with dialectical walls. Transmitting and receiving antennas of the radar were pointed to the box.

The signal reflected from the animal was recorded for further processing. Distance between antennas' block and carton was approximately 1 m. Such short distance was caused by relatively small scattering cross section of an animal. Video signal was recorded also by means of a simple web-camera placed over the box. Information about behavior and movement activity of the animal during the experiment recorded by the camera was used for comparison with and identification of radar signals. This gives possibility to recognize different type of animals' movement and its behavior.

Two albino female rats 4 months old were used as experimental animals.

Several short term experiments were carried out, during which all types of animal's behavior were present. Data base of such signal is used for creation of a signal processing algorithm, which should be able to recognize vertical and horizontal movements of a rat automatically.

3. RESULTS OF THE EXPERIMENTS

Below the results of the experiments are presented. In Figure 2 record of radar signals reflected from the animal is shown. Periods of steady state and movement activity can be well recognized even without any additional processing.

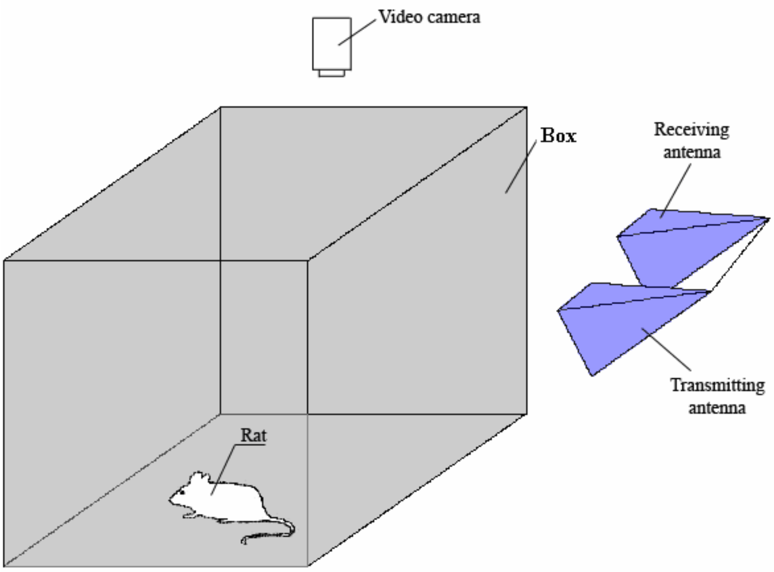

Figure 1: Sketch of the experimental installation.

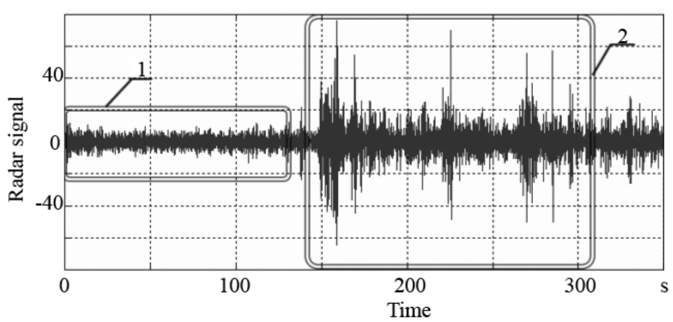

Figure 2: Radar signal reflected from an animal (1 — steady state, 2 — physical activity).

For further processing special algorithm for space focusing were created. This algorithm is used for estimation the distance to the object of investigation. The result of the signal processing in this case is “range-frequency” matrix. The cells of the “range-frequency” matrix where object is located contain information about frequency spectrum of the received signal.

Specific frequency spectrums for different animal condition were obtained. They are given in Figure 3. The spectrums differ one from another greatly by magnitude and form. That is why it is possible to distinguish grooming from steady state, sleeping or active movement of the animal. To make it easier to compare the frequency spectrums for different states of the animal, amplitude of the frequency spectrum is represented by using of nonlinear scale for vertical axis that is proportional to square root of amplitude.

In Figure 3(a) the spectrum for active movements of animal is presented. During the experiment the rat was exploring internal space of the box floor. It was moving along walls of the box and sometimes took vertical positions. The main feature of the received frequency spectrum in this case is its maximum amplitude. It is much higher than for any other state of the rat. In Figure 3(b) the spectrum for a steady state is given. It is clearly seen that the maximum amplitude in this case is more than 3 times lower than for the active movements. During the experiment the rat was calmly sitting in the corner of the carton and rarely moved its head or turned.

Figure 3(c) presents the spectrum while the rat was sleeping. Power of the received signal in this case is extremely low. But because of fact that the animal was not moving at all the breathing harmonic of the rat can be seen on the spectrum. The breathing frequency of the rat during sleeping was 1.5 Hz. This is in good agreement with available data [5].

Spectrum for grooming movements of the rat is given in Figure 3(d). The specific feature of the spectrum is a local maximum near 4 Hz. There is no any published information about typical frequencies for grooming. But radar measurements give experimental results that grooming frequency band spans from 2 to 4 Hz and greatly depend on time of day. During daytime the grooming frequency was lower at for night. The main problem of this type of movement is that

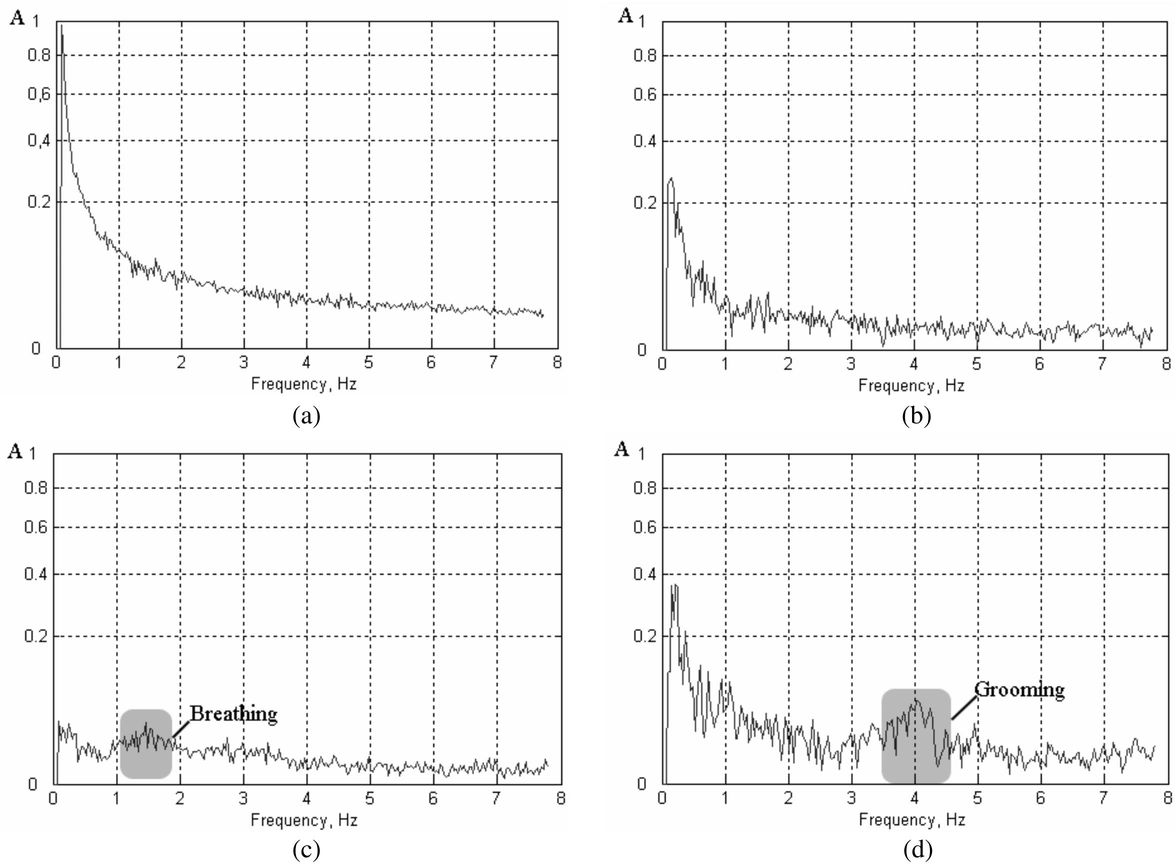

Figure 3: The frequency spectrums amplitudes A of the radar signals for animal’s different conditions ((a) — active movements, (b) — steady state, (c) — sleeping, (d) — grooming).

the animal can turn during grooming very intensively and these movement artifacts may mask the valid signal.

4. CONCLUSIONS

Bioradiolocation can be used for estimation of movement activity of small laboratory animals. It is possible to distinguish different states of animal. It was shown that while sleeping breathing frequency of the animal can be estimated without any additional procedures. This could be enough for control of animal state in pharmacology.

At present algorithms for vertical and horizontal rats' movement activity is under construction. After creating such algorithm it will be possible to use bioradiolocation not only in pharmacology, but also in zoo-psychology for observation of animal movement in the open-field.

A new bioradar is supposed to be created. It will operate at higher frequency band of 14–15 GHz. This would increase resolution capability of the radar at experiments with small laboratory animals and thus improve the quality of received information.

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