Visual perception of spatial objects and textures in flying pigeons

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Abstract

Many studies examine different cases of perception of visual elements as significant objects, borders, textures, as well as filtration of many of the observed elements as just noise. Spatial perception can be considered at the level of behavior and at the level of brain activity.

To understand the complex spatial orientation it is necessary to study not only short-distance movements (indoors locomotion), but also medium-distance movements, such as pigeon flights. Pigeon trajectories during medium-distance flights are determined, in particular, by the visual perception of the terrain.

This work considers the hypothesis that visual perception of external environment affects reactions of birds during medium-distance flights, which is reflected in pigeons' trajectories. Simultaneous comparison of data from external environment, on pigeon trajectories and on activities in the brains of birds helps to determine which elements of landscape can be a stimulus for bird navigation. Responses to basic spatial elements appear at the level of place cells, head direction cells, grid cells and a boundary cells [1]. Visual perception of more complex scenes is represented in total brain activity [2]. GPS tracks are often used to examine pigeon's ability to consider visual landmarks and to change navigational behavior [3].

In this work, data on the flights of pigeons and remote sensing data for terrain over which these flights took place were used as primary source materials. Data packages were collected from Dryad Digital Repository (http://datadryad.org). Satellite images in the form of OpenLayers (http://openlayers.org) were used to obtain surface information. This work showed that pigeon’s flight paths may reflect specific areas and objects in terrain. Here, we calculated typical time delays in pigeon responses after perception of visual stimuli during flights, and described characteristic reactions to visual stimuli for the intervals ~10 seconds. As a result, it was shown that the response characteristics vary depending on the ability of the pigeon to visually detect separate elements of the terrain during flight. So, it is possible to identify the features of birds’ response both to single landmarks and to boundaries of different surfaces. Analysis of visual perception of landscapes, textures and landmarks in flying pigeons helps to better understand how spatial features are represented in the mind during motion.

GPS TRACKS OF PIGEON FLOCK

Pigeon trajectories during medium-distance flights are determined, in particular, by the visual perception of the external environment. Flight trajectories of pigeons can reflect the characteristics of terrain areas and surface objects.

In our previous works [3], we studied the properties of pigeon flight trajectories combined natural and urban areas. The size of clusters was found to be large as for the questions.

Which properties of the terrain are guided the pigeons in flight and it is possible to identify sets of significant objects and areas based on the data about flight path?

Spatial analysis of flight trajectories and directions was applied to identify frequently used “flight corridors” and regions of interest along the birds’ flight.

The visual characteristics territories over which pigeons flew were calculated using remote sensing data. To confirm detection areas along flight trajectories, the following questions were asked: Was it found that the “flight corridors” correspond to real objects and areas in the territories.

DYNAMICAL CHANGES AND CHOICE OF ROUTES IN FLIGHT

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This work considers the hypothesis that visual perception of external environment affects reactions of birds during medium-distance flights, which is reflected in birds’ trajectories. Simultaneous comparison of data from external environment, on pigeon trajectories and on activities in the brains of birds helps to determine which elements of landscape can be a stimulus for bird navigation. Responses to basic spatial elements appear at the level of place cells, head direction cells, grid cells and a boundary cells [1]. Visual perception of more complex scenes is represented in total brain activity [2]. GPS tracks are often used to examine pigeon’s ability to consider visual landmarks and to change navigational behavior [3].

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GIS applications

Geographic information system (GIS) allow the handling of the flight path with reference to the locations and terrain features, including:

- Process GPS data with precise spatial reference to terrain.
- Calculate variation in directions of motion and in neighbour distances by vector data.
- Build summary diagrams of the dependence of different flight parameters with reference to time and to coordinates along the flight trajectories.
- Calculate the terrain features obtained from remote sensing data-such as the boundaries between different types of terrain, or the density of special points on the surface in the form of a heat map.

Deviations near stimulus

- Histogram of standard deviation deviations, in relation to the moments of flights. The x-axis shows the timescale in relation to the moment of the flight. The y-axis shows the standard deviation of the distances between pairs of pigeons, deg.
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References