Chapter 8

Detection of Landmarks by Mobile Autonomous Robots Based on Estimating the Color Parameters of the Surrounding Area

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ABSTRACT

Remote detection of landmarks for navigation of mobile autonomous robots in the absence of GPS is carried out by low-power radars, ultrasonic and laser rangefinders, night vision devices, and also by video cameras. The aim of the chapter is to develop the method for landmarks detection using the color parameters of images. For this purpose, the optimal system of stochastic differential equations was synthesized according to the criterion of the generalized variance minimum, which allows to estimate the color intensity (red, green, blue) using a priori information and current measurements. The analysis of classical and nonparametric methods of landmark detection, as well as the method of optimal estimation of color parameters jumps is carried out. It is shown that high efficiency of landmark detection is achieved by nonparametric estimating the first Hilbert-Huang modes of decomposition of the color parameters distribution.

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INTRODUCTION

The mobile autonomous robots (MARs) navigation in unknown terrain in the absence of GPS requires, in particular, the remote detection of landmarks that are concentrated in surrounding space (concentrated landmarks). For this purpose, low-power radars, laser and ultrasonic rangefinders, night vision devices and technologies are used, and in the daytime, also video cameras, images of which are processed by methods of objects recognition. The video cameras installed at the robots are effective tools for the landmark detection, if its shape is known in advance. With such a restriction, no landmarks can be found at all, since only single objects have a strict shape and their number is usually not large. Even the landmarks that are perfectly recognizable under ideal conditions can be partially covered by tree branches, vegetation, etc. Robots must make their own decisions about an object detection and assigning it to the landmark of some type. Such systems are, in particular, radars, the physical basis of which is the radiation and reception of waves reflected from the surrounding area. However, together with the echo signal from the landmark the unwanted signals, reflected from the surrounding area, enter the receiver input.

In the navigation process, the mobile autonomous robot must determine its coordinates with respect to fixed or moving objects, the coordinates of which are always known. In the absence of GPS, the reference objects may be pillars or other objects placed in the natural environment (single tree, small rock, etc.). The first task of the MAR is to detect a landmark with probability of correct detection exceeding a certain level. The second task is to measure the range to the landmark and its azimuth with a given accuracy. This chapter of the monograph deals with the first task. In the broad sense, this is interpreted as the robot automatic detection of individual objects that are concentrated in terrain and are significantly different from the background in some parameters or features. The type of parameters depends entirely on the technical means used to solve the landmark detection task. A single landmark near which no other similar objects and background differs radically from the landmark (the first terrain type) is best identified.

Let’s imagine a metal pillar in front of the forest or other inhomogeneous surrounding area. It is easy for a person to visually distinguish this object from the background. The use of radars, laser and ultrasonic rangefinders is not always advisable, since electromagnetic and ultrasonic waves are reflected from both the background and the landmark and are very slightly different in their parameters (amplitude, spectral structure, etc.). A radar with a frequency at which resonant scattering of waves from a pillar occurs has a better chance of detecting a landmark using the energy characteristics of electromagnetic waves. The systems that can detect landmarks by amplitude jumps in the process of scanning the space are complex and may not always provide the necessary probability of correct landmark detection (Poliarus et al., 2018). If the latter is a non-metallic pillar, then its probability detection on the background of the rugged terrain and forest is low. Measurement of thermal radiation of terrain elements does not significantly increase the probability of detecting landmarks.

In a real environment, it is very difficult to detect a fixed landmark against the background of stationary objects. However, from physical considerations it is clear that the criterion of detecting such a landmark against the background of the surrounding terrain in the daytime may be its color. Hence, there is the need of investigating the possibility of detecting such landmarks based on the color criterion (Abdellatif, 2013). The color parameters of real objects are random and heterogeneous in space. In the process of scanning the space with a camera, they change randomly, and if there is a concentrated landmark in the camera review sector, one or more parameters can be changed abruptly. This may be a sign of a decision for the landmark detection (Poliarus et al., 2018). The methods of detecting and estimating the parameters
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