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SECTION 13.
AUTOMATION AND APPLIANCES MAKING

Vladyslav Yevsieiev
Doctor of Engineering Science, Professor,
Department of Computer-Integrated Technologies,
Automation and Mechatronics,
Kharkiv National University of Radio Electronics, Ukraine

Oleksandra Luchaninova
4th year student, Department of Computer-Integrated Technologies,
Automation and Mechatronics
Kharkiv National University of Radio Electronics, Ukraine

DEVELOPMENT OF THE ENVIRONMENTAL VISUALIZATION SYSTEM BASED ON ESP32-CAM

One of the promising areas of our time in the development of robotics is the development of humanoid robots [1-2]. Research in this field makes it possible to synthesize various directions of modern technologies, such as computer vision systems, systems for identifying and recognizing objects based on neural networks, control, and decision-making systems under uncertainty [3].

In his work P.S. Febin Sheron proposes a method of human-robot interaction (HRI), which makes it possible to implement the visualization of the space surrounding the robot in the form of a 3D image for the operator [4]. The proposed solution has great potential, but its use for research on small robots such as Doit ViVi [5] is impossible due to the limitation of overall dimensions.

The work of Riccardo Adamini shows an example of mobile robot control implementation using a computer vision system [6]. The authors used the Robot Operating System (ROS) as a base, therefore, for the implementation of such a system, it is necessary to use a single-board computer of the Raspberry Pi 3 Model B+ [7] or Banana Pi M3 A83T [8], which requires strict power control (5V., 2A) and is not suitable in terms of overall dimensions for the problem being solved.

Based on the embedded in design limitations of the overall dimensions of the Doit ViVi humanoid robot, it is necessary to implement a computer vision system with the following parameters: minimum overall dimensions, support for a camera with a resolution of UXGA (1622×1200), support for wireless information transfer protocols. Analyzing the existing solutions on the market of microprocessor technology, the characteristics of the following boards were examined in detail: pyAI-OpenMV 4 H7 [9], the average price ranges from $295-300; M5Stack ESP32 PSRAM [10], average price ranges from $70-84; ESP32-CAM [11], the average price is between $10-14. Based on the features and price put forward, the ESP32-CAM was chosen to solve the problem.

The next step after choosing a board for implementing the environmental visualization system of a mobile humanoid robot is the development of a block diagram, which is shown in Figure 1.

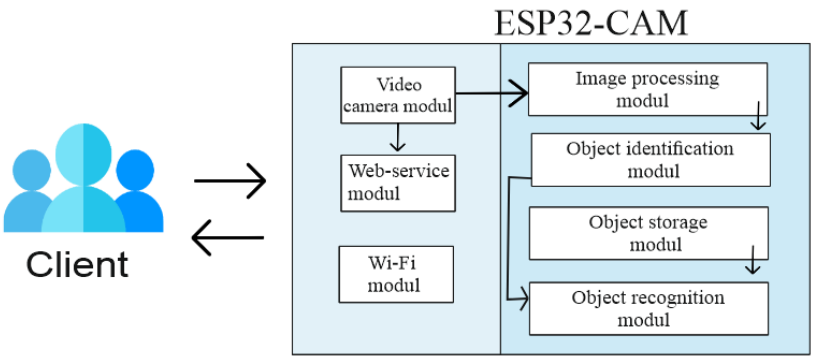

Figure 1. **The structure of the environmental visualization system of a mobile humanoid robot based on ESP32-CAM.**

The proposed structure is based on the following hardware and software modules:

- Video camera hardware module is designed to receive information about the changes in the environment of a mobile humanoid robot in the form of streaming video.
- Wi-Fi hardware module allows transferring information to the operator (Client) through the access point, which is implemented using ESP32-CAM.
- Web-service software module implements the connection and transfer of information to the operator by specifying the ESP32-CAM IP address in the operator's Web Browser.
- Image processing software module processes the video stream from the camera by selecting every 3 frames out of 30.
- Object identification software module performs object identification using decision trees.
- Object storage module is designed to store image reference templates on a microSD card.
- Object recognition software module performs object recognition in a mobile humanoid robot field of view. The results of the work are transmitted to the operator's Web Browser.

The human-machine interface (HMI) of the operator is proposed to be implemented based on the object-oriented programming languages approach like C++ [12-13].

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