ARCHITECTURE OF ROBOT WITH EMPHASIS TO 3D VISION SYSTEM

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ABSTRACT

The paper describes architecture of robot with emphasis to the vision systems and offers an explanation of its levels. Also is given to understanding of the 3D camera sensor principles based on its parallel geometrical arrangement.

Key words: Sensing, vision systems, robot, sensor

INTRODUCTION

Due to the rapid changes in the manufacturing environment, there has become a growing need for integrated vision based systems and automated robot trajectory motion control. A vision-based CCD sensor system can be integrated with an industrial robot to sense an object's profile and manipulate the robot's position online, according to the object profile, resulting in increased robot flexibility and system performance.

Vision (other names include computer vision and artificial vision) is an important sensor technology with potential applications in many industrial operations. Many of the current applications of vision are in inspection, however it is anticipated that vision technology will play an increasingly significant role in the future of robotics [1].

ARCHITECTURE OF ROBOT

The architecture of robot in the context of vision consists of function modules that observe by sensors, programmable units, control system and others (see fig. 1) that represent environments based on information, analyze the representation by using knowledge databases, plan actions and execute planned actions.

Primary engagement of robot architecture is based on managing through control system of robot, which contains in addition also from an actual management of power section to drive management.

The control system is connected through interbus to the module inputs and outputs that control the closing and opening of pliers and also the flow of coolant into them.

External part of control system is programmable unit "Pendant". This unit is used for robot programming and visualization of robot state.

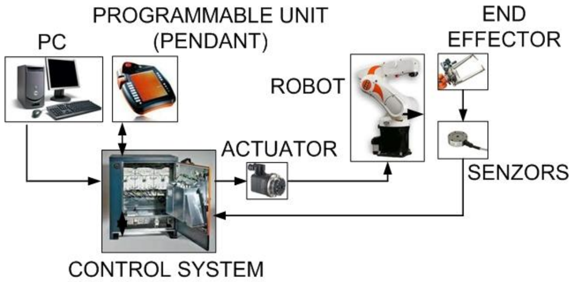

Fig. 1 The architecture of robot

LEVELS OF ARCHITECTURE

Architecture of robot assigns levels of organization to the controllers within a robotic system. Each level sends control signals to the level below and feedback signals to the level above. The levels become more elemental as they progress toward the actuator. Each level is dependent on the level above it for instructions, fig. 2.

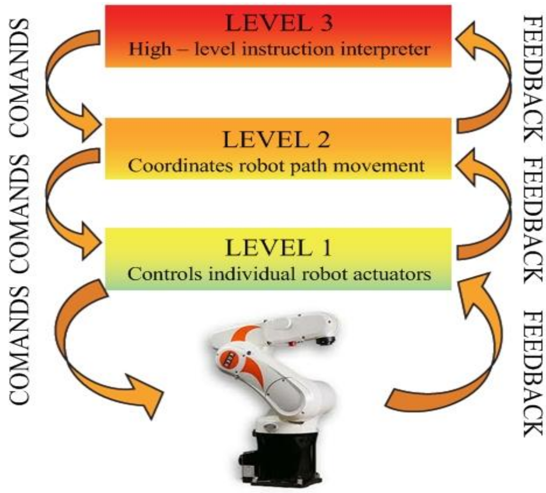

Fig. 2 Levels of robot architecture

The three levels are:

- Level 1 - Actuator Control. The most elementary level at which separate movements of the robot along various planes, such as the X, Y, and Z axes are controlled.
- Level 2 - Path Control. The path control (intermediate) level coordinates the separate movements along the planes determined in Level 1 into the desired trajectory or path.
- Level 3 - Main Control. The primary function of this highest control level is to interpret the written instructions from the

human programmer regarding the tasks required.

The instructions are then combined with various environmental signals and translated by the controller into the more elementary instructions that Level II can understand [4].

The commands of levels architecture issued by the control system activate the motion control mechanism, consisting of various controllers, amplifiers, and actuators. An actuator is a motor or valve that converts power into robot movement.

This movement is initiated by a series of instructions, called a program, stored in the controller's memory.

The function modules are connected in a line and the information processed by each module is sent to the next module. Thus, sensing and action are coupled through various intermediate representations.

VISION USED THROUGH 3D CAMERA SENSOR

The use of a 3D camera sensor allows a robot to interact with its environment in a flexible manner. Vision systems designed to be utilized with robot or manufacturing systems must meet two important criteria which currently limit the influx of vision systems to the manufacturing community.

The first of these criteria is the need for a relatively low-cost vision system. The second criterion is the need for relatively rapid response time needed for robot or manufacturing applications, typically a fraction of a second.

Robot sensing is divided into two functional areas, internal and external states:

1. Internal State Sensors – deal with the detection of variables such as arm joint positions, which are used for robot control.
2. External State Sensors – deal with the detection of variables, such as range, proximity and touch.

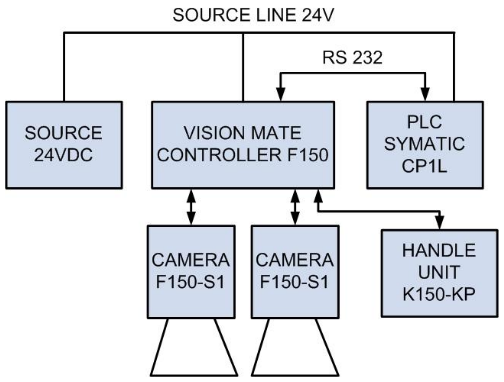

Fig. 3 Block diagram of 3D vision system

The block diagram on fig. 3 shows principle of 3D vision system engagement. Power supply provides the necessary power supply for camera control units, and also supplied with the PLC system. Camera control unit is primarily designed for image processing of the connected cameras (1 or 2 cameras).

Secondary possible linkage of these cameras in a 3D system can coordinates the processing of either PLC or in the additional links vision controller mate to a PC, where the software to transfer information from 2D to 3D camera coordinates. The link between PLC and control system of cameras is via bus 232.

The basic geometrical principle of 3D scanning vision is shown on fig. 4. It consists from two camera sensors placed side by side. The object before them is captured and digitized. The orientations of captured object are intersecting and their axes of vision are parallel [2].

Distance between camera sensor and target can be calculating through the distance ratio between cameras (b) and reference plane from the camera (r) to absolute difference between measured displacement (a) and (c). Then:

$$Z = \frac{(b \times r)}{|a - c|} \qquad (1)$$

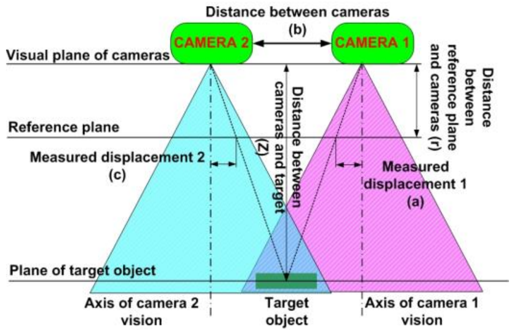

Fig. 4 Geometrical principle of 3D vision

Although proximity, touch and force sensing play a significant role in the improvement of robot performance, vision is recognized as the most powerful of robot sensory capabilities. Sensing of environment by using 3D vision system for parallel distribution of camera sensors is shown in Fig. 5.

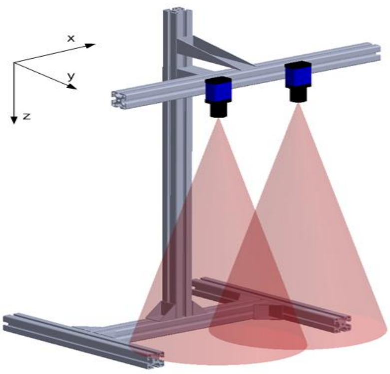

Fig. 5 Testing of 3D vision parallel camera sensors

Camera sensors can be used with robot in these applications:

1. Quality control and measurement of part dimension.
2. Detection, position and orientation of chaotically arranged parts.
3. Monitoring of process (welding, assembly.)
4. Inspection and check of integrity at least two parts.

APPLICATION OF 3D CAMERA SENSOR

The object is scanned at the workplace with 3D camera sensor and image data obtained from the transformation is applied to adjust the image so that it is decomposable [3].

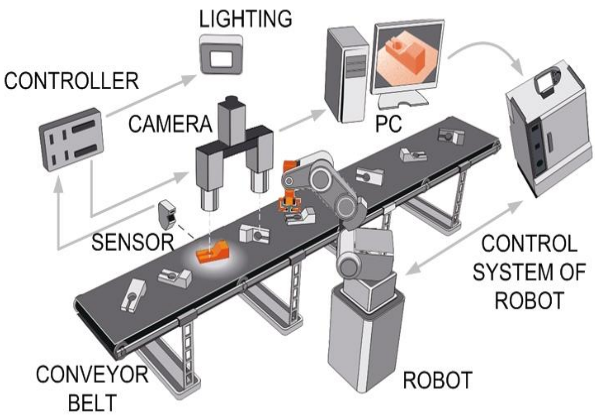

Fig. 6 Application of 3D external vision system on robot

Individual parameters will be searched in distributed status, and also will be determined the characteristics of the subject. Position of points, which indicates the object is obtained after their detection. Three dimensional locations of points (see fig. 6) can be calculated based on image recognition through industrial 3D camera sensor with two lenses [5]. This information can be used for measuring of dimensions, thickness, position and orientation.

Using a camera sensor mounted directly on the robot and adjustable light intensity we can functionally works in the full six axes of freedom in 3D. The robot is programmed to place a camera sensor and adapt lighting to the achievement of optimal image capture.

Developed software processes the image and sends it via Ethernet directly to the robot control system [6]. This approach to visual processing brings the benefit especially in the smart handling of parts, which eliminates the need of storage the components in a specified position which in the final sum significantly reduces work times.

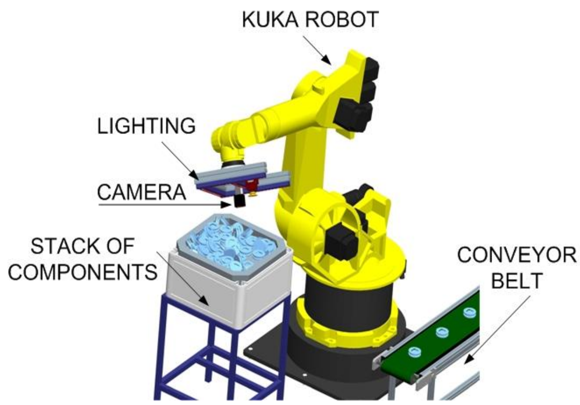

Fig. 7 Intelligent manipulations of chaotically arranged components

On Figure 7 is shown the proposed principle of intelligent manipulation of the parts that are chaotically arranged in a stack of pallets. With the camera sensor is image captured and further evaluated. Image recognition of components is needed mainly to smooth hold with effector and also for handling to the conveyor belt.

CONCLUSION

Advances in vision technology for robotics are expected to broaden the capabilities to allow for vision-based guidance of the robot arm, complex inspection for close dimensional tolerances, improved recognition and part location capabilities.

These will result from the constantly reducing cost of computational capability, increased speed and new and better algorithms currently being developed. The field of computer vision was one of the fastest growing commercial areas in the latter part of the twentieth century.

3D camera vision is a complex and multidisciplinary field and is still in its early stages of development. Advances in vision technology and related disciplines are expected within the next decade, which will permit applications not only in manufacturing, but also in photo interpretation, robotic operations in hazardous environments, autonomous navigation, cartography and medical image analysis.

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