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# INTELLIGENT ROBOTIC ASSEMBLY BY ACTIVE VISION SYSTEM INTEGRATED WITH CAD

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**ABSRACT**
*This paper proposes the concept which emphasizes the application of the active vision system integrated with CAD system. The active vision system enables acquisition of the scene image from different viewpoints. Therefore, the scene is described with more information which can provide advanced scene interpretation. Second key element of the proposed system is integration with CAD system. The integration enables the recycling of product knowledge created during the process of product development and stored as a CAD model. Proposed concept enables the generation of the recognition paradigms as different projection views from 3D virtual product by "standard" computer graphic methods. Created views represent a knowledge base for training of the robot vision system established on artificial neural network.*
**Keywords:** assembly automation, robotic assembly, machine vision, artificial neural network, CAD, artificial intelligence, PDM.

## 1 INTRODUCTION

The mechanical assembly process represents one of the most demanding tasks in production technology domain, since it requires the application of complicated handling operations in conjunction with intelligence and adaptability. These abilities are inherent to human beings and very difficult to implement into machines. Some of the key abilities which support intelligence and adaptability of the human beings are the perception and interpretation of surrounding world. Therefore, the attempt to implement the similar skills to the automated assembly devices seams to be reasonable challenge which could guide to the achievement of autonomous working systems.
Human beings use visual information as one of the most important resources to get the perception of the environment. Like technical solutions have always been inspired by nature, human visual abilities are tried to be implemented in to machines. This, to some extend, gives machines intelligence characteristics inherent to humans. Technical implementations of visual perception are known as machine vision or artificial vision system.
This paper presents the concept of the system for intelligent robotic assembly in the disordered robotic environment with special attention given to the application of active vision system and integration with CAD system.
Active vision system is active participant in its local environment. Active participation in local environment means the ability of image sensor to alter its spatial position and optic parameters regarding current environment conditions [1]. Recognition process at active vision systems is based on multiple images, acquired at different view ports.
Basic idea of the proposed approach is to increase the quantity of the information at the input of the recognition system. This is accomplished by active vision system ability to change the spatial position of the camera.
By integration with CAE system, the quantity of information used to structure knowledge required for the recognition process is increased. Further more, all the effects according to integrated engineering approach are accomplished [2].

## 2 THE CONCEPT OF INTELLIGENT ROBOTIC ASSEMBLY WITH ACTIVE VISION SYSTEM

The proposed concept of intelligent automatic assembly system for work in disordered environment combines the industrial robot, camera, robot controller and computer. The CCD camera is mounted on the robot arm. PC computer is used for vision system application and robot arm path planning application. The schema of the system is given on Figure 1.

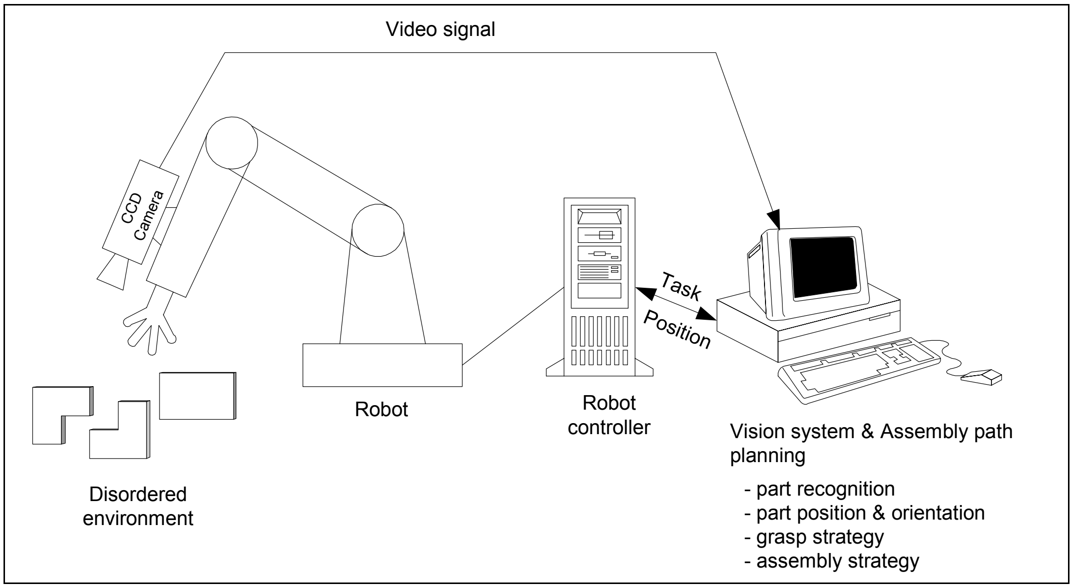


Figure 1. System for automatic assembly in the disordered robotic environment.

System is designed to assemble the product, with the robotic arm, from randomly located parts inside its working space. The purpose of the vision system, in the presented concept, is to recognize the parts that are to be assembled. Furthermore, the vision system has to determine the parts positions and orientations.

## 3 VISION SYSTEM AND CAD INTEGRATION

The basic task of the vision system is object recognition. The term recognition is related to the ability of identifing objects and events, as a result of previously acquired knowledge. Generally, the knowledge is set of information describing features of objects and events. Recognition process is based on extraction of features of unknown object and comparison with the features of the known objects. One of the approaches to the recognition problem is recognition with artificial neural networks. Neural network based recognition is just one of the recognition techniques based on the classification [3].

Design of neural network classifier is composed of two distinct phases. First one is design of the neural network architecture, and second is training of the network.

Artificial neural network is trained with input data set. At vision system application, input into the network is visual information, and network answer is its interpretation. For correct interpretation of input data, training data set must cover all of the problem classes. Increase of the diversity and quantity of the visual information at the training phase, improves the quality of the neural network answer [4].

It is not trivial task to create training data set by camera, since it must contain, beside the images, data describing spatial relationship between the camera and object. Therefore, it seems reasonable to use the synthetic images of the object for the training. The synthetic object images, together with data which interpret given scene correctly, exist or can be easily generated from the related CAD model. The CAD model describes all geometrical and therefore all visual characteristics of the object. Modern CAD/CAE systems facilitate visualization tools for photorealistic simulation of product visual characteristics. *Figure 2* a) presents synthetic image of the object, and *Figure 2* b) presents the image of the same object but acquired by camera. Presented synthetic image is created with Dassault Systemes *CATIA* visualization tool. Similarity between two presented images is obvious (*Figure 2.*).

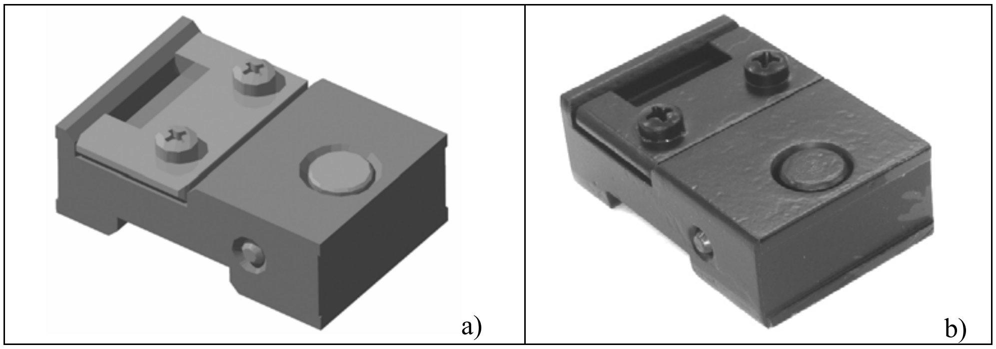


*Figure 2. Synthetic a) and real b) image.*

The usage of synthetic images establishes the data associativity between CAD model and the recognition system (Figure 3). The knowledge needed for network training is created by generating large quantity of synthetic images together with data describing relative position of view port and the object. The process of creation images from different view ports can be automated by simple macro program.

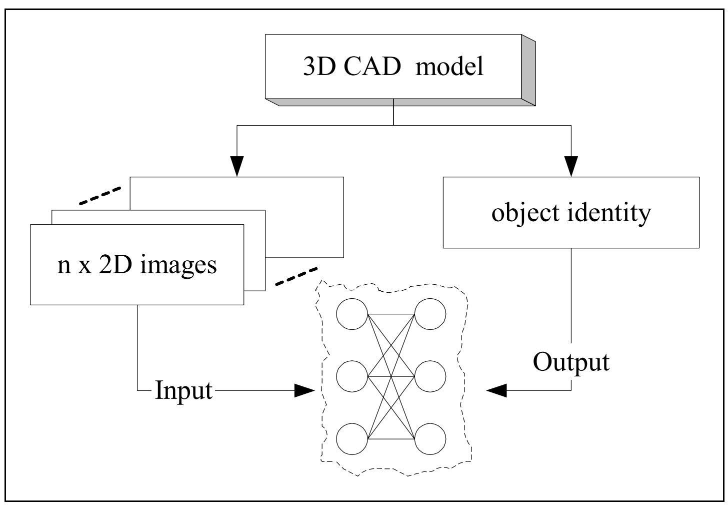


Figure 3. Data associativity between CAD model of the product and recognition system.

## 4 RECOGNITION STRATEGY

Recognition strategy consists of two phases. Phase one is based on the active vision system which is supposed to give the information that describe the presence of the parts to be assembled, including their position and orientation relative to the camera. During that phase the camera position could be altered, until the acceptable image is acquired. The acceptable image is an image which can be successfully interpreted. When object orientation is known, robot and camera are oriented perpendicular to the part. Perpendicular position is the position where camera axis and grasping axis are parallel.

When the camera is located perpendicular to the object, the second phase of the recognition process can begin. The second phase is based on the robust and precise commercial 2D recognition algorithms. It results with reliable information about part to be assembled position and orientation and enable the collision free grasping.

Recognition strategy is illustrated on Figure 4.

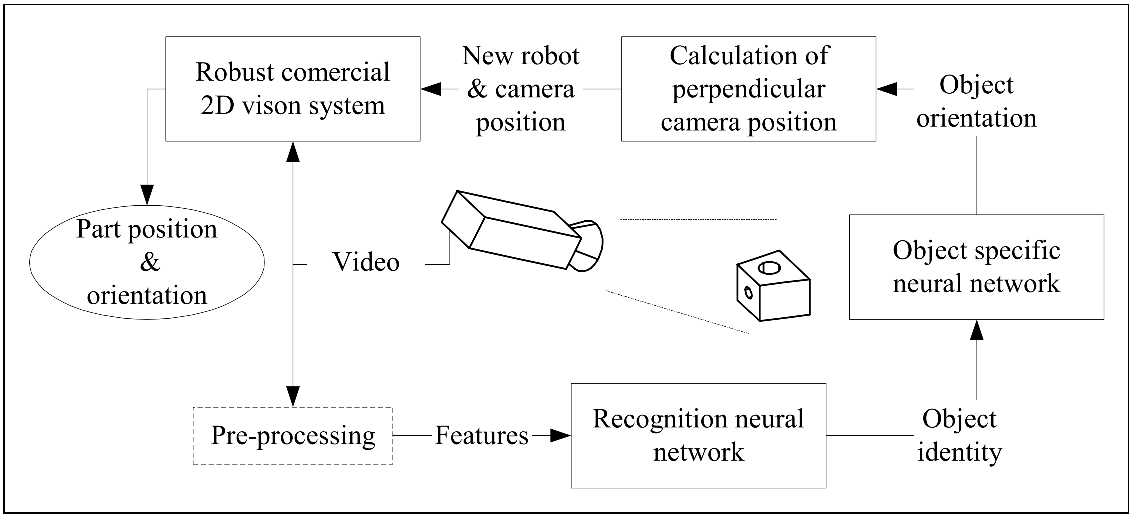


Figure 4. Recognition strategy

Video signal from the camera is digitized with the frame grabber. Both, 2D and 3D applications get the input images from it.

In the 3D system, image is preprocessed for extraction of the object contours. The contours are input data to the neural network which is supposed to give an answer about the object identity. The next step is the calculation of the object's relative orientation. Relative orientation of the object regarding the camera is defined by three Euler angles. In the proposed system only two of them are required, yaw (υ) and pitch (φ). The object specific neural network is responsible to providing the required Euler angles. That network is trained with synthetic images, same as general recognition network.

Homogeneous transformations can be used to determine position of the robot arm where these angles are equal to zero. In this position the camera axis is parallel to the grasping axis, and existing 2D recognition algorithms can be applied [5], [6].

## 5 CONCLUSION

The proposed system represents the concept of a novel approach to intelligent control of flexible automated assembly equipment (robots), in disordered or partially ordered environment. The single most important characteristic of this approach is active vision system. This is the fundamental tool for acquiring the information about local environment needed for the control programs of assembly devices.

The recognition system is based on the artificial neural network. The creation of knowledge, required for the training of the neural network is based on the extraction of visual and geometrical data from the CAD model of related object. Such approach decreases the total information entropy, contributing the extensive application of concurrent engineering principles.

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