A Flexible Multi-Robot Behavior Based Packaging System Integrated With Machine Vision
Moti Perry, Omer Sagy, Reuben Gertner, Edan Yael
Dept. of Industrial Engineering and Management
Ben-Gurion University of the Negev, Israel

Abstract
In this research a flexible multi-robot production cell is implemented in order to perform packaging missions. The production cell is aimed at making packages that consist of different shape and color parts. The main target is to achieve maximum productivity and uniform work distribution among the robots. The user defines the packaging mission for each robot in advance. The cell includes three identical robots and a central information system that receives part identification from a machine vision system which enables also to perform quality control process and defects detection. Decentralized control is employed - a local control system rules each robot. Different parts are fed to a circular conveyor and handled between the workstations. Each robot takes parts from the conveyor depending on its decision making algorithms and places the parts in a stack located nearby. The robot starts packaging when all parts are available.

In this project, two algorithms for decision making were compared. The first algorithm named 'Can-Take' in which every robot takes parts as long as it belongs the package mission. The robot will reject parts if it is busy or if there is no place in the stack. The second algorithm is 'Behavior based' in which two additional parameters are considered to determine the robot status relatively to the other robots - number of packages done by the robot and the total working time of the robot. A robot with good performance will reject parts in order to enable other robots to achieve the same performance.

Experiments were performed to compare between algorithms by feeding randomly 50 parts into the conveyor. Three feeding frequencies were used. Performance measures were productivity, uniform work distribution among the robots and utilization.

Previous researches, based on simulation models, found that 'Behavior based' algorithm is better than 'Can-Take' algorithm when the importance of uniform assemblies among robots was high. Better productivity was achieved by 'Can-Take' algorithm [1][2][3].

Analysis of experiments results validates the simulation results and shows higher productivity of the cell using the 'Can-Take' algorithm for all feeding frequencies. Higher frequency declines productivity for both algorithms since more parts are leaving the cell without being taken by any of the robots. Examining the distribution of work among robots shows certain preference for 'Behavior Based' algorithm in all frequencies. Increasing feeding frequency in 'Can-Take' algorithm, results better work
distribution since more parts are transferred to second and third robot while the first one is busy.
The production cell, as built in this project, enables to test additional algorithms as 'Fuzzy Logic' algorithm or 'Behavior based' algorithm using different behavior patterns. Optimization of other parameters characterized the cell can be also obtained.

Reference