ESKİŞEHİR TECHNICAL UNIVERSITY JOURNAL OF SCIENCE AND TECHNOLOGY
A- APPLIED SCIENCES AND ENGINEERING

2019, Vol: 20, pp. 77 - 83, DOI: 10.18038/estubtda.641674

FLEXIBLE MANUFACTURING TENDENCIES AND IMPROVEMENTS WITH VISUAL SENSORING

Artem BRONNIKOV[1], Igor NEVLIUDOV[1], Oleksandr TSYMBAL[1,*]

[1]Computer Integrated Technologies and Mechatronics Department, Faculty of Automatics and Computerized Technologies, National University of Radioelectronics, Kharkiv, Ukraine

ABSTRACT

The proposed article contains the review of modern tendencies in flexible manufacturing systems. The applications of intelligent control systems for modern manufacturing are considered. As one of key elements of production control, article deals with tasks of visual monitoring for distributed production workspaces.

Keywords: Flexible manufacturing, Robotics, Image processing, Adaptive control, Image stitching

1. INTRODUCTION

The research, development and application of flexible manufacturing systems (FMS) are the features of humanity entrance to the post-industrial stage of development. Application of FMS provides the quick and low-cost transition to the new production types output, especially for conditions of low-series production. The efficiency of FMS is determined by optimal organization of technological equipment usage, supplied by robotized and transport systems, delivering bars, details and instruments, making the required service and check of technological processes.

The mass use of FMS becomes effective only then, if with the society demands for their application, the level and culture of production reaches the certain level of quality. Commercially viable development, introduction and exploitation of FIS's and robots are still quite expensive and not possible and every factory in any country.

The existing FMS have a number of disadvantages: the control systems of FMS are too centralized; the technological equipment simulation tools are not sufficient; the tools of autonomous monitoring and control for workplaces are in stage of development as well as modules of technological tasks analyses of decision-making for particular workplace on monitoring results; there is no modules of decision-making adaptation to global of local changes of workspace of FMS states. Therefore, the level of technical and technological development of modern FMS is in-correspondent to manufacturing challenges, need more researcher attention and make researches in this field one of most perspective for modern science and technology [1].

2. SMART FLEXIBLE MANUFACTURING DESIGN

2.1. The progress of Flexible Manufacturing and Expected Results

The task of a modern production system analysis is to understand its transfer from one state to another, which is characterized by an increase stability and efficiency.

*Corresponding Author: oleksandr.tsymbal@nure.ua
Received: 10.10.2019 Published: 16.12.2019

After analyzing the development of production systems as a class of complex systems, it's possible to get the process of evolution of these systems from simple to complex (Figure 1). And the higher the complexity of such systems, the higher their effectiveness [2].

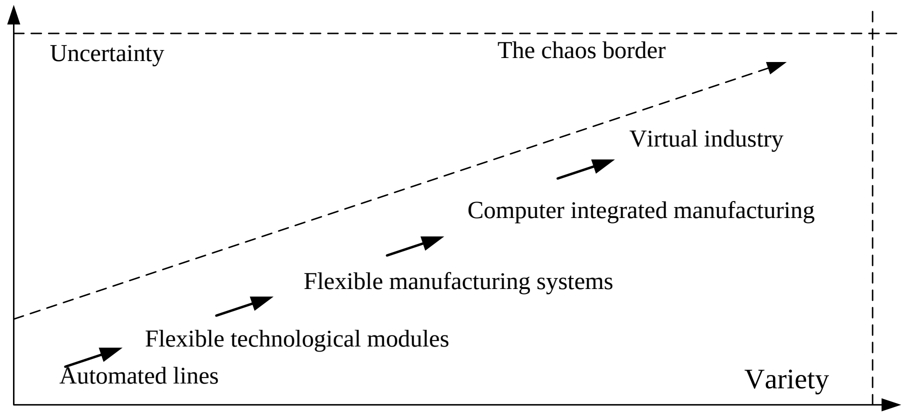

Figure 1. Flexible manufacturing systems evolution

Modernization of flexible manufacturing systems, the number of uncertain situations and the emergence of unforeseen situations increase, which can lead to a state of chaos in the system. Automated production systems will help to solve these problems.

System flexibility is ability to quickly adapt to new tasks, determined by the technical capabilities of equipment and processing technology. The advantages of manufacturing flexibility are system properties such as:
- compliance with production requirements;
- a quick transition from the release of one type of product to another;
- preservation of small-scale production;
- automation of production through computerization;
- reduction in costs of work in progress.

Flexible automated manufacturing should have the following features:
- ability to work well with various external and internal changes;
- ability to easily incorporate new equipment into the system to increase capacity in connection with an increase in production;
- possibility of expanding the processing of various types of parts;
- ability of the system to take into account changes in the composition of technological operations;
- ability of the system to function during readjustment in machines
- ability to uninterrupted and optimal loading of metal-cutting equipment according to a specific management strategy;
- ability of the system to flexible tool change;
- rational construction of processing routes and traffic flows, in accordance with the criteria of optimality;
- possibility of a simple and immediate transition to the processing of any of the parts mastered by the system.

2.2. Flexible Manufacturing and Introduction of Intelligent Technologies

The next stage of modern manufacturing systems development is mostly considered in way of introduction of intellectual systems of manufacturing control. For best understanding of "intellectual manufacturing systems", they can be compared to FMS. Currently, the automated manufacturing system is manufacturing system with different levels of automation for manufacturing and non-manufacturing processes, different levels of integration for subsystems [3]:

- technological (technological equipment collection);
- transport and manipulation (with implementations by industrial and manipulation robots, robocars);
- supervision (connected to devices without tools of process supervision);
- checkout (checkout function for all devices and systems).

The application of intellectual manufacturing systems is conditioned by effectiveness of all their subsystems.

The intelligent manufacturing system is a system with inbuilt capability for adaptation to accident workspace changes, for instance for production list, market requirements, technology changes, social needs. However, intellect of such systems is often understood as software control but not as implementation of modern artificial intelligence technologies. Intelligent manufacturing systems include the systems similar to the same of FMS: technological, transport, manipulation. Subsystems are equipped by tools that supply the certain intellectual level. IMS must be considered as highest FIS level.

IMS has the next functional possibilities [2]:

- intellectual design;
- intellectual supplement of technological operations;
- intellectual control;
- intellectual scheduling;
- Intellectual support of processes.
-

The purposes of IMS introduction are:

- manufacturing costs decrease;
- production time decrease;
- easy integration of new processes, subsystems and technologies, their update, operational interaction supplement;
- decrease of production defects, of industrial pollutions;
- Quick re-configuration, adaptation to predictable and unpredictable events.

In automation, the assembly operations have the most complexity. The determination of sequences to catch, to orient and position the parts of assembling system in conveyer is quite simple for human but is complex enough for manufacturing systems. The absence of general tools to deal with unordered workspace in FMS is compensated by use of delivery systems, palettes or specialized conveyers [3, 4]. The requirements to IMS development include the open architecture with modular structure that allows using the different methods of knowledge representation and its integration to manufacturing systems, to processes of decision-making and of knowledge acquisition.

IMS have to integrate the following methods and technologies of knowledge processing and of decision-making:

- artificial neural nets, which are AI-tool, able to simulate the complex function, human brain learning procedures;
- fuzzy logic – the set of technologies and methods to formulize the natural language, the linguistic and numerical data processing;
- Genetic algorithms and evolutional simulation methods, that include the learning algorithms, based on theoretical achievements of evolution theory, enriched by AI-methods.

The combination of mentioned symbolic knowledge presentation methods with expert system gives possibility to form complex software to solve decision-making problems at every stage of manufacturing functioning.

The structural organization of IMS is based on basic rule of OOP, which matches the processes of information and programming. Also, it assumes that the development process is based on conceptual object description and includes the method of development and introduction for computer-integrated manufacturing CISMOSA (Open System Architecture for CIM), developed by a number of EU projects.

The intellectual control system (as a part of IMS) can be considered as distributed control system in a next way:

IMS = <M, R(M), F(M), F(IMS)>,
where *M=<Mi>* - the set of formal of logical-linguistic models, presenting the certain intellectual functions;
R(M) — the function of needed model choice (or of model set) for the certain situation;
F(M)={F(M)i} — the functions set for models modification;
F(IMS) — the function of ICS and of its basic components (*M, R(M), F(M)*) modification.

Therefore, the modern tendency in manufacturing systems development is in the application of technical tools with bio- and human-similar properties (intelligence, experience, recognition and can be introduced by application of IMS. IMS can be created as opened structures, which unite the existing information systems with subsystems, using artificial intelligence to form the integrated environment to solve the IMS problems. Simultaneously, the improvement of adaptive and intellectual tools of technological and supplementary equipment, for instance of industrial and transport robots make necessary to advance the mathematics, organization, algorithms and software for decision-making systems of robotized systems.

2.3. Visual Targeting

The control system takes into account changes in the working environment and conditions. A flexible manufacturing integrated system should oversee the execution of tasks and, if necessary, adapt the process of fulfilling the production functions of the robotic devices [5].

As such a system, an adaptive visual control system may be included. The introduction of such adaptation system has significantly important characteristics of robotic systems control that are part of the flexible manufacturing system.

The main problems of any of which flexible manufacturing in our time is Automated transport operations, both within one workshop (single-zone system) and between workshops (multi-zone systems).

The company's manufacturing workshops have wide open spaces, both between manufacturing equipment and wide corridors. Hence, the possibility of integration for transport operations of flexible computerized manufacturing modules – intelligent robotic objects.

Such modules will be added from Mobile robotic platforms and sensed systems installed both globally (computer vision systems) and on the robotic platform itself (GPS, rangefinders, etc.). The use of such systems will significantly increase the speed of the implementation of transport operations, which will positively affect the manufacturing itself.

The advantages of computer vision systems using are the low cost of the equipment used – there is no need to use a huge number of expensive sensors for orientation in the workspace.

According to the dynamic nature of the intelligent robotic object working space, the visual control system should provide an analysis of the working space for moving the transport-assembly work. The dynamic nature of the transport and assembly working space, is determined by the conditions of mechanical assembly production, imposes adaptation requirements, which should provide increased stability of flexible integrated production systems.

The visual control system of an intelligent robotic production should provide the following features:
- work with the camera / cameras (connection and setup);
- image processing;
- image analysis;
- classification of the working area objects according to the results of image analysis;
- formation of a model of movement of objects of the working area;
- prediction of the further trajectory of the movement of objects;
- allocation of impassable sites;
- route formation;
- supply of control actions;
- assessment of navigation errors;
- elimination of navigation errors.

The coordinates of the target point are obtained by visual targeting and consist of the following:
- obtaining information about the workspace (geometric parameters)
- obtaining information about the camera workspace (image parameters, reads with the help of technical vision system (TVS));
- conversion of spatial coordinates to camera space coordinates (TVS)
- recognition and identification of the robot in space (both in the workspace and in the space of the camera)
- indication of the starting point of movement on the image obtained with the help of TVS;
- indication of the end point of the movement on the image obtained with the TVS.

2.4. Image Stitching

If the workspace is very large, the information about it will be obtained from several cameras.
Let there be a working space of an intelligent robotic object equipped with a set of video cameras (computer vision systems), and the working spaces of all cameras intersect in some areas (Figure 2).
Figure 2 demonstrates colors indicate workspaces where cameras receive an image.
Images received from the camera are stitched in panoramic.

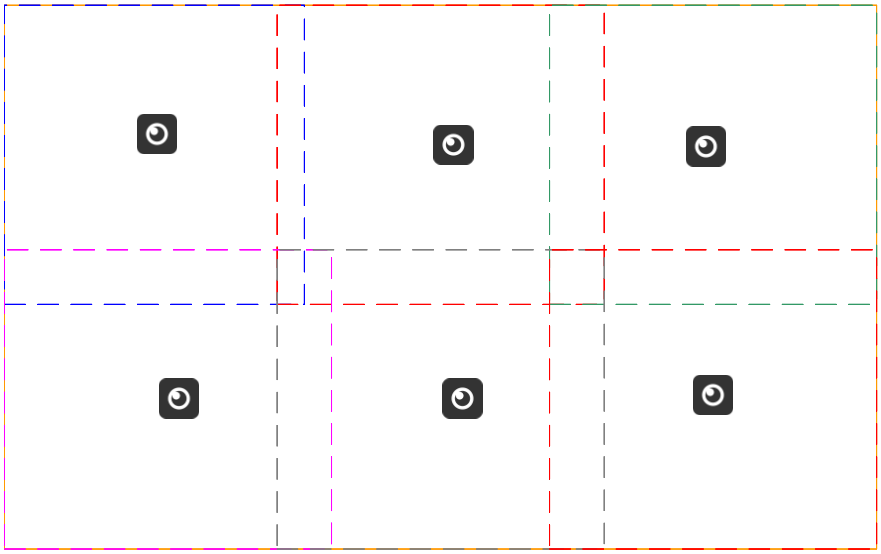

Figure 2. Workspace with few cameras

There are several cameras in the workspace (WS), the image of each of them may differ in several parameters, such as:
- matrix resolution;
- type of matrix;
- values of brightness and contrast;
- sensitivity;
- viewing angle;
- frame rate, etc.

It follows that the image or streaming video coming from the cameras can have various parameters, which makes it difficult to stitch it into one image for further work.

As a stitching algorithm (panorama building), it is proposed to choose the SIFT (Scale Invariant Feature Transform) algorithm.
The algorithm consists in finding singular points in the image and their descriptors.
Singular points are those points that are likely to occur in another image.
Descriptors are parameters of singular points, distinguish them from others, the so-called uniqueness of each of the points.
To find the singular points, it is necessary to calculate the Gaussians (applying Gaussian blur to the image) and their differences.

The mentioned descriptions and definitions formulate the model of workspace of FMS, including:

– objects of WS (object's coordinated, direction and velocity, class of object, technical state, ability to use for decision execution);
– states of WS (topographies, available paths and their conditions, obstacles and their changes, fallouts, lighting etc.).

Therefore, visual sensoring becomes the key element of intelligent control of modern FMS.

3. CONCLUSION

Currently, the development of automated control systems for FMS has reached the certain level of structural organization and automation. The next steps for Flexible Automated Sectors (FAS) development can be in the introduction of intellectual technologies, which supplies more manufacturing flexibility, especially for low-serial production, with next phased transition to automated factory concept. To solve the problems of operations and process control, of production monitoring the application of modern visual-guided control systems can be considered as one of key parts of intelligent production control.

REFERENCES

[1] Nyevlyudov I, Tsymbal O, Chochowski A, Lysenko V, Reshetiuk V, Komarchuk D, Kuliak B. Methods and Models of Intellectual Decision-Making Support for Automatized Control of Flexible Integrated Manufacturing / Kiev: Agrar Media Group, 2016. – 356 p.

[2] Veselovska N, Strutinkii V. The perspectives of computer-integrated manufacturing systems. Naukovi Notatki; 2009, vol. 25, 11-15.

[3] Kerak P. Novel trends in the intelligent manufacturing systems. Proc. Of 8th International Baltic Conference “Industrial Engineering”, 19-21 Apr., 2012, Tallinn.

[4] Tsymbal O. Decision-planning for robot control system. Vestnik of Sevastopol GTU, 2009, vol. 95, pp. 124–128.

[5] Tsymbal A, Bronnikov A. Decision-making in Robotics and adaptive tasks. Proceedings of IEEE East-West Design & Test Symposium (EWDTS’2012), pp. 417-420.