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PROPOSAL OF A VISION SYSTEM FOR AUTOMATED LINE MPS 500

Urgency of the research. *Research needs from this area are based on designing of effective and affordable vision system solution with aim of automation level increasing in content industry 4.0 and should be an advantageous solution mainly for SMEs. In overall, development direction in vision system area pointed to the necessity for innovative technologies implementation that starts from supply chains up to customers.*

Target setting. *Main aim of article is to propose a solution for image processing of selected assembly parts at specified automated line from FESTO company to automate monitoring and evaluating of obtained data together with supporting of educational activities for field: „automation and control of machines and processes“ of our students, at other hand.*

Actual scientific researches and issues analysis. *Currently, vision systems have enjoyed a great popularity, their implementation into the automated lines grown up and application range more and wider. Supporting from manufacturers is strong, so far, we consider that useful and well-priced solution will be benefit in research area.*

Uninvestigated parts of general matters defining. *Existing realized and implemented solutions are based on solid whole concept from suppliers, starting from connectivity through image processing up to evaluation of situations (pictures, state etc...).*

The research objective. *Purpose of an article is to provide an alternative proposal for implementation of affordable and alternative vision system solution into the selected automated line from FESTO company.*

The statement of basic materials. *Most of realized projects are based on complex vision system solution. Customized and well – priced proposal are rarely, so, we consider, that should be useful to contribute into research community in form of an article from this area.*

Conclusions. *Presented article offer fundamental deployment of vision system into the automated line from company FESTO with aim of intelligence level increasing of this line. Last, but not least, purpose of automated line will be educational training with focus to experimental verification of students knowledges, primarily from pneumatics, compact PLC and vision system, of course.*

Keywords: *camera system; automated line; assembly process; vision system.*

Fig.: 4. References: 9.

Introduction. Recent development in process automation emphasizes deployment to innovative technologies implementation, starting with supply chains and ending with customers. These efforts also affect assembly process; as a result of which previously used manual inspection methods for various objects were replaced by automated inspection and also measurement have been changed. In the past, trained worker was inspecting product and inspection at automated lines was only performed on only individually selected object or product. The result at output of line was a series of poor quality products, which simply did not pass sufficient control and consequently got to the next stage of processing, respectively in case of final operation, directly to the customer.

However, with increasing of requirements for object quality, demands on measurement and control process have also increased [1]. Older measurement techniques are slow, inconvenient and impractical today. Moreover, they are characterized by lower reliability and unnecessarily increase final price of final product. Therefore, in quality control and similar routine activities, traditional forms of vision control are replaced by machine vision (figure 1) even with higher initial costs. Main advantages of machine vision systems are their speed and accuracy. These systems are able to perform inspection without time loses on at the automated line, which allows quick and transparent checking of all objects without time consuming.

Fig. 1. The example of machine vision at automated line [2]

The concept of machine vision deals with optical inspection at an automated industrial systems. Reliability of this inspection is mainly determined on the devices parameters selection such as camera, lens, lighting, PC and appropriate software use. The application of machine vision is constantly increasing today and in practice it is applied in various application areas. It allows easier and more efficient work control and it can works at high speeds under high precision conditions. With such a vision system it is possible to perform more experimental measurements and also continuously checking of one captured image [3]. Machine vision is used for detecting of object properties such as shape, surface quality or reading characters, bar codes and printing. Typical applications for image processing from vision systems are:

- Checking of presence, colour and shade of object.
- Evaluation of dimensions, shape or description of object.
- Error detection, light intensity measurement, motion and position control.
- Checking of other tasks according to the customer specifications.

The object for vision system monitoring can be practically everything, e.g. a screw on conveyor belt, a biological sample or cookies in boxes, etc. Machine vision is used primarily in automation and it is used for monitoring of quality production, detecting of defective products or control, while ultimate goal with required characteristics is achieved. Vision system scans object and evaluate obtained image by itself or sends scanned image to computer for further processing and assessing of accuracy [4].

Vision system at automated line. Proposed intelligent vision system can be characterized as compact device in which a complete machine vision system is integrated. It provides all functions from capturing of first image through processing up to evaluating and sending of results via Internet. It is also capable for solving of demanding tasks and can perform several different inspections simultaneously. It includes a microcomputer, which takes care for an entire camera system. Communication with environment is provided via PROFIBUS, Ethernet or programmable digital inputs and outputs.

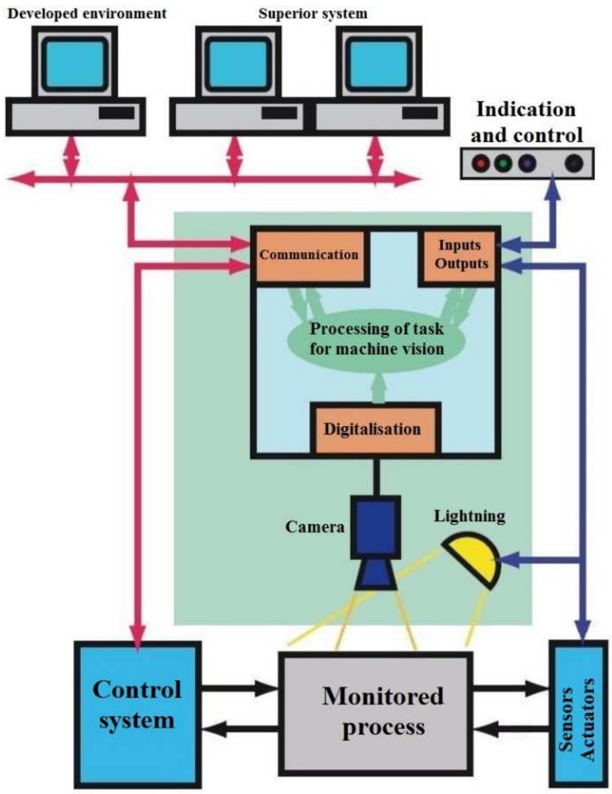


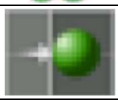
Fig. 2. Implementation of vision system at automated line MPS 500

This vision system is also equipped with a serial interface that allows communication with a compact PLC. The inspection process is created at standard computer with the help of software supplied by manufacturer [5].

This software is then loaded into the vision system memory. The biggest advantage of vision system is increased mechanical resistance in consequence with its deployment in industrial environments. Choosing of specific type of vision system was dependent mainly on affordability, free version of configuration software and transparency of its activities. With aim of this, functional comparison of selected vision system can be seen at table 1.

Table 1

Functional comparison of selected vision system

Symbol of tool	**Title**	**Description**	**BVS-E Advan**	**BVS-E Univer**
	Check brightness	It compares average brightness value in region of interest with setting of minimum and maximum values.	X	X
	Compare contrast	It compares maximum contrast value in region of interest with setting minimum and maximum values.	X	X
	Check contour	It checks if outline (shape) of current part matches outline with reference image.	X	-
	Count edges	It calculates edges in the area of interest and checks if number of edges is between available minimum and maximum.	X	X
	Compare width	It compares width in pixels between two edges and checks if it lies between available minimum and maximum.	X	X
	Pattern detect	It searches matching pattern corresponding to pattern from reference image and counts number of times, where pattern appears in region of interest.	X	X
	Check position	It looks position of first edge in the area of interest and checks if it lies between accessible minimum and maximum.	X	X
	360° Defect finder	It calculates similarity between desired contour and contour of interest. Deviations between them are detected with great accuracy. The contours to be checked can also be selected during parameterization.	-	X
	360° Count Contours	It searches and counts all outlines whose resemblance to the desired outline if is greater than specified value. The position in image and its angle of rotation are output for each contour.	-	X
	Optical character verification	It checks presence and correctness of "learned" characters.	-	X
	Read barcode	It reads following barcodes: Interleaved 2-of-5, Code 39, Code 128, Pharmacode, Codabar, EAN 8, EAN 13, UPC-A, UPC-E.	-	X
	Read datamatrix code	Reads datamatrix Code: Datamatrix ECC 200.	-	X
	Read QR Code	Reads QR codes and Micro-QR codes.	-	X

Since the task is to select an economical advantageous vision system, the lower price for BVS-E type is an important factor in selection of system. However, it is also necessary to take into account functions of compared vision systems, their usability for deployment to the MPS

500 automated line and possibility of future exploitation in education of students in laboratory, where Festo MPS 500 automated line is located [6].

Selected vision system has integrated evaluation electronics, illuminator and two digital outputs. It combines functions of BVS-E Ident and BVS-E Advanced vision systems into the single device, which greatly simplifies spare parts supply and allows it for using of almost any inspection task. The result of inspection is signalized by two states (OK and an Error). This signal is transmitted via digital outputs, Ethernet or RS-232 interface. Universal vision system can locate and verify up to 40 barcodes per second, regardless of their position. Collected data from reading codes are transmitted through interface for further processing (image, shape, etc.). Thanks to the Optical Character Verification (OCV) function, we are able to verify printed letters and numbers of selected vision systems to obtain information on the batch or object expiration date.

Fig. 3. Chosen vision system BVS-E Universal from Balluf Company [7]

This vision system comes with different lens versions. One of the latest innovations is the compatibility with infrared light. The wavelength of integrated light is shifted from original 630nm to the new limit of 870nm, which is classified as invisible to human eye that will certainly be appreciated by any employee working near a similar facility. A standard feature is an integrated light filter that prevents ambient light from affecting of unit control quality and thereby increasing process reliability [8]. Power supply and peripherals of vision system are connected with two proven standard industrial M12 connectors. Table 2 shows technical specification of vision system.

Table 2

Technical specification of BVS-E Universal vision system

Camera system code	BVS UR-3-001-E
Picture sensor	CMOS - monochromatic
Resolution of sensor	640x480
Object lens	8 mm
Working range	50-1000 mm
Vision field	24x18 – 480x360 mm
LED colour, wavelength	Red, 633 nm
Voltage Us	24 V DC ±10%
Current with no load, Io	Max. 200 mA pri 24 V DC
Switching outputs	3x PNP - Transistor
Digital inputs	1x Trigger,1 x Select
Interface for parameter setting	1x M12 4-pin – Ethernet 10/100 Base T

Automated line MPS 500. This automated line from FESTO Company introduce a comprehensive solution for automation of assembly process, both for educational purposes and for scientific and research activities. It contains many input and output devices and actuators, what makes it an ideal training place for engineers and technicians from industry. It is designed to cover many technical possibilities related to the issue of modern automated lines that are usually used in industry, see figure 4. The automated line consists of 5 stations: 1 - distribution and testing station, 2 - process station, 3 - assembly station with robot, 4 - handling and sorting station, 5 - transport system.

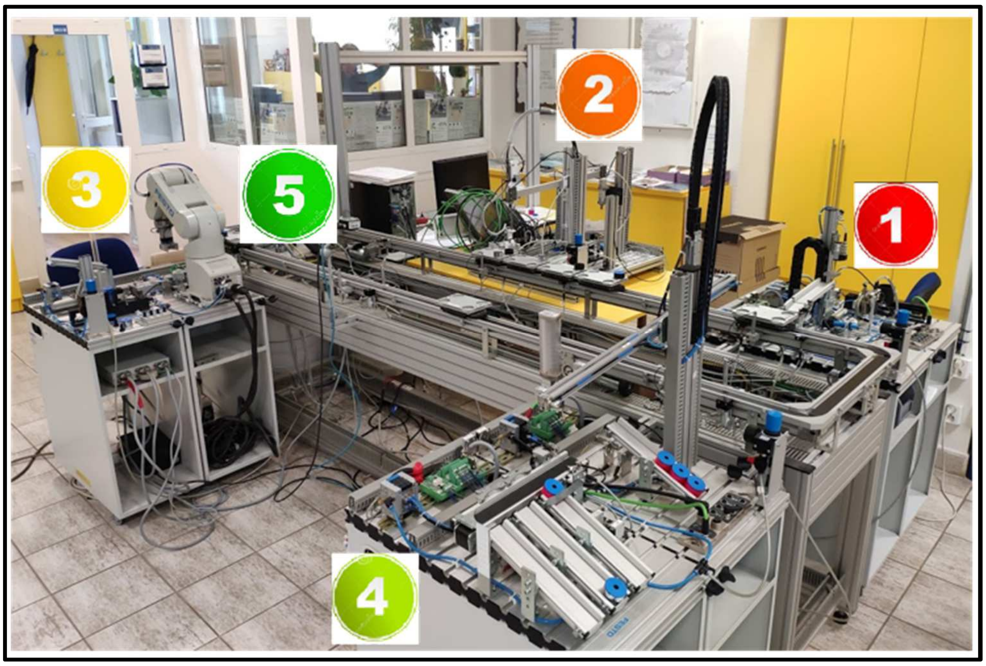


Fig. 4. Automated line MPS 500 at Department of automation and human machine interactions, TUKE:
1 - distribution and testing station; 2 - process station; 3 - assembly station with robot; 4 - handling and sorting station; 5 - transport system

Automated line verifies basic principles of pneumatic and electrical systems, their control and mutual communication between individual stations. Thanks to the Mitsubishi RV-2AJ robot station, it is also possible to focus on the basics from standard industrial robots programming. The main advantage of MPS 500 line is its modular concept. Line configuration uses all available stations; its centre is a conveyor belt at rectangular ground plan [9].

Conclusions. The installation of a vision system on an automated line MPS 500 assumes object recognition and subsequent signalizing on light beacon. Solution assumes connection with a compact PLC from Siemens. From a constructional perspective, system is coupled to the respective rack at corresponding height above the line. Initial testing showed a poor scanning speed of vision system. Regarding to this situation, we decide to scan objects in a static position with help of pneumatic piston to stop the movement.

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ПРОПОЗИЦІЯ СИСТЕМИ МАШИННОГО ЗОРУ ДЛЯ АВТОМАТИЗОВАНОЇ ЛІНІЇ MPS 500

Актуальність теми дослідження. *Потреби в галузі контролю якості виробів ґрунтуються на розробці ефективного та доступного за ціною варіанту системи машинного зору з метою підвищення рівня автоматизації контенту в індустрії 4.0. Це має бути вигідним рішенням переважно для малих та середніх підприємств. Загалом напрямок розвитку в області систем машинного зору вказувало на необхідність впровадження інноваційних технологій, починаючи з ланцюгів постачання виробів споживачам.*

Постановка проблеми. *Головною метою статті є пропозиція рішення для обробки зображень вибраних складальних деталей на заданій автоматизованій лінії від компанії FESTO для автоматизації моніторингу та оцінки отриманих даних разом з підтримкою освітньої діяльності в галузі «автоматизація та управління машинами і процесами» для наших студентів.*

Аналіз останніх досліджень і публікацій. *В даний час системи машинного зору користуються великою популярністю, а їх впровадження в автоматизовані лінії та області використання постійно розширюються. Спостерігається значна підтримка з боку виробників, щодо питань дослідження різноманітних рішень у даному напрямку.*

Виділення недосліджених частин загальної проблеми. *Існуючі реалізовані рішення базуються на цілісній концепції від постачальників, у яку входить обробка зображень та цілісна оцінка ситуацій (загальний вигляд, стан тощо).*

Постановка завдання. *Метою статті є надання пропозиції щодо впровадження доступної та альтернативної системи машинного зору у вибрану автоматизовану лінію від компанії FESTO.*

Виклад основного матеріалу. *Більшість реалізованих проектів ґрунтуються на комплексному рішенні системи машинного зору. Індивідуальні та недорогі пропозиції систем машинного зору зустрічаються досить рідко, тому дослідження особливостей їх використання та аналізу стану виробів будуть корисними для науковців в цій галузі.*

Висновки відповідно до статті. *Представлена стаття пропонує проект системи машинного зору для автоматизованої лінії від компанії FESTO, що з її застосуванням підвищить рівень контролю якості. Крім того, використання запропонованої автоматизованої лінії у навчальному процесі покращить якість засвоєння матеріалу студентами та дозволить проводити експериментальну перевірку їх знань, насамперед, з пневматики, компактних ПЛК та систем машинного зору.*

Ключові слова: *система камер; автоматизована лінія; процес складання; система машинного зору.*

Рис.: 4. Бібл.: 9.

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