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Introduction to Low Cost/Cost Effective Automation

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I. INTRODUCTION

The contributions to this issue aim to provide robotics and, in general, the automatic control community with results of research and applications focused on the cost-effectiveness of automation systems.

Low Cost Automation or Cost Effective Automation promotes cost oriented reference architectures and development approaches that properly integrate human skill and technical solutions, includes decentralized process control strategies, addresses automation integrated with information processing, as well as automation of non-sophisticated and easily handled operations for production maintenance.

Low Cost Automation is not an oxymoron like military intelligence or jumbo shrimps. It opposes the rising cost of sophisticated automation and propagates the use of innovative and intelligent solutions at an affordable cost. The concept can be regarded as a collection of methodologies aiming at exploiting tolerance of imprecision or uncertainties to achieve tractability, robustness and, in the end, low cost solutions. Mathematically, elegant designs of automation systems are often not feasible because of neglecting real world problems, i.e. they are failure-prone and therefore often very expensive for their users.

Low Cost Automation does not mean basic or poor performance control. The design of automation systems considers their life cycle with respect to their costs. For example, machine vision, despite in some cases costly components, properly applied can reduce the overall cost. It is used to guide field robots, identifying and assembling parts, and to sort out agricultural products.

The reliability of low cost automation is independent of the grade of automation, i.e. to cover all possible circumstances in its field of application. Often it is more suitable to reduce the grade and involve human experiences and capabilities to gap the bridge between theoretical findings and practical requirements. On the other hand, theoretical findings in control theory and practice foster intelligent solutions with respect to saving costs. Anyway, reliability is a must of all automation systems, but this requirement has no one-to-one relation to cost. Therefore Low Cost Automation, as a cross-sectional field in automatic control does not, in the main, develop new control concepts but uses combinations, together with an integration of information and communication technology.

Low cost automation also involves the implementation of an automation system. This should be as easy as possible and besides it has to facilitate maintenance. Maintenance is very often the crucial point and an important cost-factor to be considered. A standardization of components of automation systems could also be very helpful to reduce cost, because it fosters the usability, the distribution and innovation in new applications.

The contributions of this issue are devoted to cost aspects as follows:

II.1. On Cost-effectiveness of human-centered and socially appropriate robots and automation systems

This contribution explains the objectives of human centered and social appropriate automation. Both are not a contradiction to cost effectiveness. It points out that the design for the engineer and the application for the user of automation systems will soon become justifiable in tangible as well as intangible benefits for all. A changing understanding regarding the future use of robots and automation systems is forecast. This requires a significant re-orientation to new technology design paradigms that will suit better the new situations, in particular with respect to considerations about what in the future will be an affordable and cost-effective technology. The analysis and discussion of these aspects is done qualitatively, but a quantitative analysis is demanded here and will be subject of further research.

II.2. Computer vision and robotics techniques in fish farms

Computer vision properly applied reduces the cost of handling biomasses as demonstrated in fish farming. The proposed systems use simplified models based on fish features, and existing relations between the fish size and their weight. This approach has significant advantages for its simplicity, modularity and flexibility to adapt to different fish species. Besides, it needs lower computer requirements than other segmentation methods based on 3-D models or active contours. The paper presents several low cost systems for fish farm automation.

II.3. Image-to space path planning for a SCARA manipulator with single color camera

Computer vision is also the main subject to guide a SCARA robot to sort and manipulate fruit. It replaces humans in routine and boring work and could be more reliable in sorting out, thus reducing rubbish going to the market. The method proposes a two-step algorithm for estimating the object position on the image plane and then mapping it into space to find required angular values of the manipulator joints. Hardware and software implementations of the present method involve low cost when compared to current commercial technology.

II.4. Low cost automation using INS/GPS data fusion for accurate positioning

Accurate positioning is a requirement for autonomous vehicles to be cost effective, applied indoors or outdoors. The fusion of signals coming from INS and GPS provides the necessary accuracy. The paper presents the method of sensor fusion based on Adaptive Fuzzy Kalman Filtering. The method is suitable for real-time control and is relatively inexpensive. Also, it applies to a fusion process with sensors different from INS or GPS.

II.5. Solving the inverse dynamic control for low cost real-time industrial robot control applications

The presented real-time control architecture is applied to the control of an industrial robot. The new and open architecture is based on a PC, and any control technique can be programmed and implemented. The provided total open architecture is not expensive compared to commercial solutions.

II.6. Using distributed systems in real-time control of autonomous vehicles

Real-time control of autonomous vehicles is discussed using fieldbus technology for connecting sensors, controllers and actuators. This is cost effective because of reducing the number of connections that are necessary in conventional architectures. The fieldbus protocol will become widely used in several applications, including autonomous vehicles, due to availability and cost reasons. A navigation architecture capable of providing an intelligent motion control of autonomous vehicles conceptually described has been partly tested in a RobChair prototype.

II.7. Innovative control education using a low cost intelligent robot platform

Control education traditionally needs a lot of special devices in the laboratories. A robot platform is shown that can be configured for different applications, therefore reducing expenditure. The paper presents the application of innovative control education and building a laboratory using low cost equipments. The architecture and control system of a new kind of a low cost intelligent robot, “Ability Storm”, is introduced. It not only shows the technical details, but also illustrates the related applications in control education.

II.8. Cost oriented virtual reality and real-time control system architecture

This contribution focuses on the worldwide available standard hard- and software, partly free of charge, for control education and simulation of real-time control experiments. This avoids the costly commercial solutions which are mostly applicable to a restricted problem. It has been used to implement a car driving simulator used for the evaluation of a rollover avoidance controller. Another example is the control of an inverted pendulum. This setup is used as an experiment for students on an advanced control course.

II.9. New intelligent power-assist systems based on differential transmission

Power assist and motion guidance devices are new developments for cooperating humans and robots or manipulators, so called *cobots*. The cost effectiveness is considered when human skills and intelligent assistance are working collaboratively. The paper presents a novel cobotic system with a differential CVT. The new system is significantly cheaper, simpler to control and more efficient than cobots with S-CVTs.

II.10. Telecontrol system based on Smith predictor using TCP/IP protocol

Telecontrol and Teleoperating are new challenges for automatic control. The well established internet and its protocols can be used to avoid costly cabling. With an example of a remote control of a pasteurization device the contribution considers the usefulness and reliability of the protocols and measures to avoid or to mitigate the effect of time delays in data transfer.

II.11. Proactive maintenance strategy for harbor crane operation improvement

Maintenance costs are considered in connection with the overall costs of running an enterprise. A compromise between time for maintenance and the other enterprise tasks has to be considered in order to optimize the whole process (manufacturing, transport, etc.). A proactive maintenance strategy is presented and illustrated for a harbor crane operation.

II.12. Smart devices for manufacturing equipment

The problem of developing smart or intelligent devices as sensors and actuators with integrated information processing are presented and the cost savings against conventional sensor-controller-actuator architecture are discussed. Very small components, such as inputs/outputs blocks and overload relays, are too small to integrate data processing for technical-economic reasons. The paper presents the development of embedded intelligence and control for the smallest factory floor devices. The decentralized architecture offers easy commissioning and maintenance.

III. CONCLUSIONS

The papers in this issue show that Low Cost Automation or better Cost Effective/Cost Oriented Automation opens, indeed, a cross-sectional field of automatic control. Cost are the critical issue in the design and development of new components, instruments and the layout of automation systems with respect to their life cycle. Decreasing costs of smart components and computer hardware and software technologies are promoting significant changes. Cost is also critical for the applications of robotics and autonomous systems in many sectors. In addition, automatic control requires ever more information-intensive technologies to promote agility. The development of information processing and storage capabilities allows for new automation architectures based on paradigms derived from Artificial Intelligence. Also communication technologies using the internet and its protocols play a prominent role, as explained for tele-control.

Therefore life cycle assessment of automation systems with respect to total costs, integrated information processing in sensors, actuators and controllers, wireless networking

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and software agents supporting decision-making and maintenance is the main challenge for research and applications of a cost effective automation.

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