INTEGRATION OF MECHATRONICS – STRATEGIES AND SOME CASE STUDIES

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ABSTRACT

The interdisciplinary area of Mechatronics is fast integrating into the curricula of traditional mechanical engineering courses world over. Different approaches and strategies adopted by educational institutions are evident from a survey of the literature. More often it has been a process of evolution, within an existing curriculum driven by the exceptionally high demand in the industry for graduates trained in Mechatronics.

In a global context, Mechatronics is often seen as the future career for Mechanical Engineers and in Sri Lanka even in the present meager state of industrialization, the industry opportunities for engineers with a strong electro-mechanical background needs no speculation. However, in the local context there are severe resource constraints to successful implementation of a Mechatronics programme.

This paper examines the issues involved in relation to global trends and local constraints and it attempts to identify possible avenues for development. The current project-based learning approach used in the authors' department to introduce mechatronics is presented covering some specific case studies involving different sectors of industry.

INTRODUCTION

The 1990's saw a significant growth in the field of Mechatronics, which is broadly an interdisciplinary area which bring together elements of Mechanical Engineering, Electrical-Electronics Engineering and Computer Technology. By the year 2000 the diversity has been so much so that it is argued (Ref. 1) that 'Mechatronics' is a field that has no real independent identity. The situation has also been very confusing to the local industry which has a strong bias towards Mechanical Engineering implemented using traditional methods. Nevertheless, the significance and potential of Mechatronics in the present era of Electronics and Information Technology are undisputed.

CAREER PATHS IN MECHATRONICS

Traditionally mechanical engineers have been in a unique position of bridging the gap among various engineering areas (Ref. 2) because of the diversity in their training. However, as times have changed, if this status quo is to be maintained, some competencies associated with electronic and computer applications have to be acquired by the mechanical engineers. The industry demand for 'Mechatronic Engineers' who understand computer and mechanical systems as well as their interactions is high and continues to grow in the industrialized world. Therefore mechatronics is seen as a prime career path for mechanical engineers now and in the future.

It is pertinent to note that certain professional bodies in engineering have come together to form special interest groups dedicated to promote Mechatronics recognizing this truly multidisciplinary approach. The IEE / IMechE Mechatronics Forum is one such group.

STRATEGIES FOR MECHATRONICS INTEGRATION

The challenges offered to the educationist is to recognise the diversity of topics relating to Mechatronics and identify the best strategy for implementation in a particular ground situation. This needs experience and intelligent assessment of the realities for the effort to be a practical solution. Given the practical nature of Mechatronics, it cannot be taught with a classical academic approach where the normal tendency is to teach in depth the technologies, with relatively little weightage to developing skills and practical expertise. Such an approach is bound to fail and will remain 'on paper' as an excellent curriculum, but will not serve any useful purpose. A completely balanced approach based on, teaching background technologies only to the required minimum depth with more attention for developing related skills through practice & project work must be aimed at.

Teaching Personnel

The major constraint to adopting the above 'balanced approach' will be the availability of correct calibre resource personnel, ie. staff with relevant academic training and with much enthusiasm and ability to practice. Past experience shows that this is truly a scarce resource. One may have to look beyond the traditional borders of academic excellence in this regard. Many institutions which traditionally offered technically biased courses but later developed into being full fledged universities, carried with them the staff having this balanced approach. Partly this grooming was a result of sandwich type courses offered in these institutions before becoming universities. The same practices continued. Some key examples of such institutions can be found in the U.K. and in Singapore.

However, there has been many innovative approaches in the traditional universities where the academic administration had the vision to promote multi-faceted industry interaction. In this respect the University of Warwick, U.K. stands out as a unique example. Attention has been drawn to this aspect in the paper "Manufacturing Education – The Industry Interface" appearing elsewhere in this proceedings volume.

INTERACTIVE LEARNING ENVIRONMENT

In a scenario where manpower resources are likely to continue to be a scarce resource, certain state-of-the- art teaching equipment which are geared for interactive student-based learning could be a valuable asset to any mechatronics teaching/training programme. Such didactic training equipment are very common in mechatronics teaching laboratories and enables the students to grasp the fundamentals in a more practical learning environment and provides the teacher with an effective strategy.

The Department of Mechanical Engineering of the University of Moratuwa has taken some initial steps towards this by working on a project towards the establishment of an 'Automation Centre' (Ref. 3). Such a Centre could serve to fill a major void in the introduction of mechatronics and industrial automation. The component units of such a center could be, among others, a Motion Control Laboratory, PLC Training Laboratory, Electro-pneumatic Training Laboratory and Mechatronics Systems Laboratory. In a mechanical engineering environment further supplementary facilities could be a CNC Laboratory and an FMS Laboratory. In the University of Moratuwa context such a center would be an extension of the objective of the establishment of the CAD/CAM Centre in the Department of Mechanical Engineering in 1988 under a UNDP / UNIDO project.

Project-based Learning

Traditionally, the comprehensive Design Project is given much emphasis in a mechanical engineering curriculum as an opportunity available to the student to apply theory learnt in several background subjects towards a practical design. The extent to which this becomes reality depends on the focus towards design exercised in teaching the related subjects. Therefore a collective awareness of the teaching faculty of the teaching objectives of each subject is a must.

Today mechanical engineering design extends far beyond the boundaries and conventional methodologies of product and machinery design to sub-system or entire system design (Ref. 4). Integration of mechatronics with mechanical design is increasingly being considered as a practical approach to mechatronics education within a mechanical engineering curriculum (Ref. 5). Here traditional design methods combined with sensors and instrumentation technology, drive and actuator technology and computer control enables the student to appreciate the application of mechatronics to derive greater flexibility and enhanced performance from a mechanical device (Ref. 6).

The CASE STUDIES presented in the latter part of this paper highlights this approach.

Curriculum Reforms

There is more than ever a need for mechanical engineers to understand analog and digital control systems, sensors and actuators, and computer architecture and interfacing in addition to the conventional mechanical engineering subjects. However, the emphasis has to be on physical understanding rather than on mathematical detail. For example, the traditional methods of teaching Controls as a mathematical exercise with hardly any design practice will be of little value in a mechatronics scheme (Ref. 7).

The literature and available evidence shows that although mechatronics combines diverse subject areas which are taught in a wide variety of disciplines, it has evolved in the vast majority of instances through a traditional mechanical engineering base and not vice versa. Thus, in the revised semester based curriculum for Mechanical Engineering at University of Moratuwa an attempt has been made to orient students towards mechatronics by incorporating subject modules such as Applied Electricity & Electronics, Information Technology, Instrumentation & Control Systems, Mechatronic Systems and Automation & Robotics.

IMPLEMENTATION OF A MECHATRONICS PROGRAMME – THE REALITIES

Whatever the thrust on mechatronics introduction at departmental level, if a successful mechatronics programme is to emerge in a faculty of engineering, it will necessarily have to be a cross-disciplinary effort. Being mindful of the ground realities in Sri Lanka, it is unlikely that such action would be forthcoming in the short-term. This is because the mechanical engineering discipline at the present time occupies an 'underdog' position due to the low level of industrialization in the country. Although this is superficial and temporary, it has created a trend to cluster around electronic and computer oriented disciplines. Thus the collaborative thinking will come only at a time mechanical engineering discipline will be back at a position of strength, hence the initial challenge for the Mechanical Engineering Departments to develop a reasonable mechatronics base within them. In any event a strong commitment will be required from an engineering faculty administration if interdepartmental boundaries are to be overcome and a truly interdisciplinary mechatronics programme is to emerge.

CASE STUDIES

The development of the existing Controls Laboratory to teach how theories can be applied in practice in designing control systems and automated machinery is explained here. Such knowledge can be directly applied in industry. An attempt has been made to construct laboratory equipment in the department it self. All possible constructions were carried out through final year projects. Students were directly involved under guidance of the project supervisor. The control elements such as sensors & actuators and most of the other components and materials used in these projects were obtained by dismantling periodically discarded industrial machinery.

The Approach......

Some laboratory/Industrial projects carried out are as follows:

1. **PLC controlled automated feed and sort mechanism** for sorting plastic and metal parts of different heights.

Objectives:

- Make provision for students to learn functionality of a PLC (Programmable Logic Controller) and practice how to programme.
- Learn about different types of electrical & pneumatic actuators, optical & metal sensors and their functionality.
- Learn how to construct an automation process controlled by a PLC for a given industrial application and control actuators productively according to the signals obtained from sensors.

Main components and their functions:

- An induction motor driven conveyer belt & pneumatic cylinders to move parts across the working area.
- Metal sensor to identify metal parts.
- Optical sensors to identify heights and locations of the parts.
- Rotary encoder to obtain signals for determining travel distances of parts along the conveyor belt.
- PLC programmed for controlling operations of the entire apparatus.

Functionality:

The apparatus is constructed by leaving provision for testing all possible functions available in the PLC used. First the parts to be sorted are loaded to the feeder. Feeder feeds them on to the conveyor belt when there is space available on the belt. If there is at least one part on the belt, the belt motor starts to move them along the belt. While moving, these parts are detected by optical and metal sensors. Belt motor stops temporarily when an object comes in front of the appropriate tray to be loaded. Finally the part gets ejected to the tray by activating a pneumatic cylinder. Accordingly all the objects in the feeder are sorted out.

2. **Pneumatically operated electronically controlled label cutting mechanism**
for a garment factory.

Objectives:

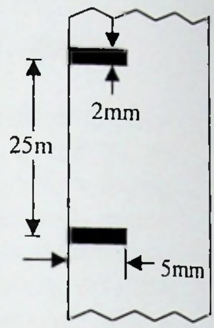
- To highlight an application of an elementary electronic comparator circuit as a controller in a very useful and productive industrial automation application.
- Learn about how a signal obtained from a reflective type optical sensor in a electronic circuit could be used to control electrical & pneumatic actuators.

Main components and their functions:

- An induction motor to drive the strip of label to the cutter.
- Reflective type optical sensor to detect the position where a cut should take place.
- Pneumatically operated cutter as an actuator.
- Pneumatic sucker to collect the cut label pieces.

Functionality:

The apparatus is capable of cutting garment ID labels and Care Labels of varying sizes as shown in the figure. The optical sensor is used to detect the black mark where a cut should take place and the electronic control circuit activates the pneumatic cutter when the black mark is at the cutter.



3. Automated road traffic light controller
demonstrates how the Internal time interrupt facility of a computer is used for real time controlling.

(a) Continuous temperature measurement of several sources simultaneously
to teach the functionality of A/D converters and how C++ programming language is used for controlling the parallel port and data handling.

- **Automation of the neutralization process of waste liquids** of a hot dip galvanizing plant where pH sensors, data acquisition and processing with C++ are implemented.

CURRENT BENEFITS

Students who acquire such design knowledge are highly appreciated by local industries and this is also very important for the development of the country. There are already a few examples of such students who managed to create new jobs (design and research) in industry.

Some practical programmes have been conducted for postgraduate diploma students who are practicing engineers. According to the feedback received from the students, there is a heavy demand from engineers in industry to gain this type of knowledge on industrial applications of Control theory and Mechatronics.

FUTURE BENEFITS

Improved relationship with local industries.
Some short courses are being planned where the constructed apparatus will be made use of for experiments and demonstrations for the engineers who are already in industry

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