AUTOMATION AND ROBOTICS IN CONSTRUCTION

STATE OF THE ART IN THE UNITED KINGDOM

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ABSTRACT

As in a number of Western Countries, the need for automation and robotic application for use in the construction industry in the U.K. has been recognised during the past ten years. The industry is experiencing increasing shortages of skilled labour and an ageing workforce. The industry is also facing demands for higher productivity and improved quality in order to meet external competition.

A number of developments covering many applications are currently in progress in some academic and industrial organisations. The range includes computer aided construction and engineering, enabling technologies and prototype development for a number of devices.

1 INTRODUCTION

It is important to reorganise the role of the construction industry and its importance to the British economy. The value of construction output in 1989/90 was in excess of £45 billion, representing more than 10% of the Gross Domestic National Product. During the same period the industry employed over one million people, accounting for approximately 5% of the total working population in this year.

It is becoming increasingly important that automation and robotics be introduced in to the construction industry. One of the serious problems facing the construction industry, is that young people are not being attracted to join the industry because they can see greater challenges from working in the high-tech industries, financial institutions and also in the service industry.

Although building and civil engineering sites are complex environments, demanding higher levels of adaptability from a wide range of plant and equipment systems, it is recognised that the gradual introduction of automation would be possible by improved planning and work scheduling and applying the principles of modern manufacturing to Construction. The introduction of Information Technology tools to the design and construction process has started to take momentum and is bound to have considerable effect on U.K. construction practice.

2 THE U.K. ADVANCED ROBOTICS INITIATIVE

Since its initiation in 1985, with the support of the Department of Trade and Industry (DTI), the three National Groups with activities related to civil engineering and construction, have been engaged in a number of studies and developments with the objectives of introducing demonstrator models and prototypes. The three Groups have completed feasibility and project definition studies covering the required enabling technologies and also have developed conceptual designs and the required outline specifications.

The Construction Group led by Taylor Woodrow at the Project Definition Stage (PDS) consisted of three construction companies, two consulting firms, a manufacturer, two technology organisations and three academic institutions. The PDS Project, completed in 1990, was a wall climbing robot, adopting a modular approach, applied to both hardward and software. The robot would comprise a set of self-contained components, each capable of a particular skill. A re-constituted group has prepared a proposal to develop a number of demonstrators to be integrated in a prototype building facade inspection robot. It is anticipated that the work will commence before the end of 1991.

The Tunnelling Group led by British Coal has considered tunnelling for both mining and civil engineering projects with emphasis on a systems approach and continuous operation. The Group has formulated a proposal to develop and to demonstrate an AR production tunnelling system which offers continuous operation through the integration of automated sub-systems. Because of financial difficulties it is likely that the commencement of the work may be delayed.

The work of the Underwater Group, which was a joint project with Italy (EUREKA 191), included the development of conceptual designs for two demonstrator vehicles. Work and Inspection robot which was based on a tethered, telerobotic vehicle for inspection , maintenance and repair of offshore structures, and for assistance with subsea engineering tasks. The second demonstrator was for a fully autonomous, untethered vehicle for survey and inspection of the sea floor. The two lead organisations were Ferranti ORE from the U.K. and Technomare from Italy. The project has not yet progressed to the implementation stage.

3 AUTOMATIC EXCAVATOR

Work has been in progress at Lancaster University to develop the technologies required for the operation of an automatic excavator including hardware and software systems. Development has included a one-fifth scale laboratory demonstrator model of an excavator arm which was used to examine various hardware and software configurations.

A knowledge base governing the use and operation of excavators and other construction plant has also been developed. It is intended that this will be used as the basis for both the high level strategic knowledge and the lower level tactical knowledge structures required for the operation of automated plant and equipment offsite.

4 SOIL NAILING MACHINE

At the University of Wales College of Cardiff, an automatic soil stabilising machine for embankments and cuttings appliction has been developed using "soil nailing" technique. The soil nailer fires it steel nails into the soil using an air launching system based on one developed by Ferranti. This can shoot the nails 25mm in diameter and up to 6 m long, into the soil at a rate of one per minute. Firing can be controlled so that the ends of the nails are arrested near the surface of the ground. The machine which operates hydraulically, incorporates microprocessor control of the firing mechanism.

5 AUTOMATION OF MASONRY TASKS

Since 1990 work has been in progress at the City University, London, to develop the enabling technology for robotisation of masonry task within quality assurance environment. The robot cell, which will be available for demonstration purposes early in the second half of 1991, will comprise a 5m x 0.6m flat bed conveyor, mortar mixing, pumping and dispensing equipment, a rotating laser and a 5 axis gantry robot with a mechanical type block gripper.

The work is being supplemented by a CAD representation of the workplace providing the means for referencing, which is being updated for the possible relocation of objects and progress in the work assignment.

6 INSPECTION OF NUCLEAR REACTORS

At the Polytechnic of Portsmouth a climbing vehicle for the inspection of nuclear reactors has been developed. The device carries forward and reverse viewing TV cameras, their lights, a manipulator and its own cables up to a vertical rough steel surface vehicle pulling a considerable pay load.

The mechanism consists of two frames, an inner frame and an outer frame each of which carries four gripper feet. The outer frame has a pair of end-frames to which are fixed two short stroke pneumatic cylinders forming the "legs". The two end-frames are tied together by a stiff tie-rod on one side and the ends of a double rod, double-acting, pneumatic cylinder on the other. The cylinder body is free to slide backwards and forwards along its rod between the end frame, Each of the legs on the end-frames have a gripper foot attached with a limited play ball joint to allow the feet to be self aligning.

7 FLEXIBLE MANUFACTURING SYSTEMS

To determine the scope for employing flexible manufacturing systems, incorporating robotics technology, on construction sites, the University of Reading has just completed a study which also involved developing a model to illustrate the automation of installing cladding systems. The philosophy adopted was based on the assumption that construction should match the requirements for automation.

The development was carried out with particular reference to the design and construction of low-rise, high-tech commercial and industrial buildings.

8 TASK SELECTION FOR ROBOTIC EVALUATION

In collaboration with a major U.K. contractor, the University of Nottingham has undertaken a study to ascertain which areas of the company's activities would benefit most from the deployment of robotic system. A technique called Qualitative Controlled Feedback (QCF) is being employed to survey a significant proportion of a company's site management, in order to evaluate the perceived benefits and restrictions associated with robotic systems.

Similar work in developing methodologies for appraising the feasible application of robotics in the construction process are also in progress at the London Southbank and Bristol Polytechnics. In these studies technical and economic issues are being addressed.

9 APPLICATION OF INFORMATION TECHNOLOGY

As in many Western Countries the application of Information Technology to the automation of design and construction practice is gaining momentum in the industry supported by research and development in academic institutions. Expert and Knowledge Based Systems have been developed to deal with planning and site management, estimating and budgetting, design detailing and project management. Studies in these areas have been in progress at the Universities of Salford, Loughborough, Dundee, Leeds, Reading, Bristol, Nottingham, Manchester and the City University of London.

10 CONCLUDING REMARKS

Most of the U.K. development in the area of construction automation and robotics has essentially been in the form of laboratory demonstrators with a very few devices developed to the prototype stage. In the area of Advanced Robotics conceptual designs have been developed for a number of devices and it is anticipated that some will progress to the implementation stage.

As was mentioned in the paper entitled "Towards Site 2000" there is a need for a test-bed site to be used as a proving ground for the introduction and integration of new technology incorporating prototype devices and new management tools.

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