Chapter 1
The Impact of Control Engineering and Artificial Intelligence in the Development of the Field of Civil Engineering

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ABSTRACT

In the recent decades, optimization, automation of processes and designs have become the focus of any field's development. With the limitation of natural resources and increasing demand for more services, it is essential to reduce any kind of wastes involved in any of the processes. Furthermore, the advancement of technologies has simplified or decreased the workload of humans and pave a road to utilize the human resources in another way where time consuming, rigorous or complex things could be done with the assistance of technologies more accurately and with improved performance as well as reduced time. This chapter highlights the way control engineering along with AI could be applied in the development of civil engineering projects. Moreover, it talks about the gaps in the recent research and how control engineering with AI can shape the future of civil engineering field.

INTRODUCTION

Before moving forward with the chapter, it is important to know about Control Engineering, which is a branch of engineering which concentrates on the way to design systems in order to attain required outputs as well as behaviours. It is also called as Control System Engineering, and in other words, it includes not only design, but also optimization in addition to analysis of control systems to accomplish the needed outputs. Whereas control systems are made up of devices which control of other systems or devices, which comprise of electronic as well as mechanical parts. Basically, this engineering branch utilizes computational tools, mathematical modeling in addition to feedback mechanisms to regulate physical systems in an effective manner. It could be understood in a way that the above-mentioned branch of engineering targets to optimize efficiency, safety as well as performance of systems throughout dif-

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ferent areas. They utilize detectors as well as sensors to estimate the output performance of controlled process. Then the estimations are utilized to give right feedback to assist in attaining the anticipated performance. Mathematical modeling of varied range of systems also acted as a foundation for Control Engineering to work smoothly on analysis, designing, in addition to optimization aspects of the control systems. As per the records, the water clock of Ktesibio in Egypt's Alexandria around the 3rd century BCE is considered to be the 1st feedback control device, making it an automatic control system. Later on, a number of other automatic devices were made for either entertainment or for beneficial tasks, for instance automata dancing figures were open-loop control devices famous in European countries during the seventeenth as well as eighteenth centuries. However, the feedback control idea by James Watt in the late eighteenth century in the year 1788, at the time to control the steam engine's speed by using flyball governor, was a major tuning point, followed by the 1st modern recorded mathematical analysis of feedback control by the closed-loop control system's inventor Nicolas Minorsky in the year 1922 was another milestone in development of Control Engineering in the modern times. By the 1930s, many areas like ships, analogue computers, airplanes, telephone systems, and so on, were using feedback control devices. In simple words, it can be said that initially Control Engineering roots started with mechanical control systems in history and with the arrival of electrical control systems, the development of this field progressed rapidly and led to the current Control Engineering branch. In a way, this branch of engineering could also be described as the one where control theory is practically applied in real life. It is important to understand that the system can be electrical, chemical, mechanical, fluid, biological or even financial one, where the analysis, mathematical modelling, in addition to controller design utilizes control theory in one or more of the realms of frequency, time, as well as complex realms based on design problem's nature. At present, Control Engineering has become an integral part of the human lives from small scale work to large scale work, which includes washing machines at the homes to wash the daily clothes which are very common household electronic items to the highly advanced fighter airplanes for aerial fights in battles and many more. Similarly, it could be said that Control Engineering aims on the modeling of a varied range of dynamic systems which are present in many areas including the area of Civil Engineering, as well as the design of controllers would help such systems to work in the anticipated way. This means that the dynamic behaviours which is present in many domains including Aerospace, Civil Engineering, etc., are controlled by analysing, designing, as well as incorporating systems with the help of Control Engineering. It helps in the factory production lines to become automated, which includes the factories responsible for producing construction equipment and materials, in addition to the way to manage aeroplane's stability which is important in air transportation of either goods, people or animals. However, to proceed further, there is a need to have an understanding of control systems in general first.

Control Systems

Control systems are the systems which are expected to control physical processes. In other words, these systems are the ones which gets input, that is being processed by them, in order to produce an output which is further being utilized by these systems to regularize the whole process. Many applications uses control systems which comprise of advanced systems responsible for managing the flight of aeroplanes in addition to regulate the temperature of indoor places by thermostats. Usually, systems are built of different components which collaborate together to attain the same goal. In the case of control systems, their components include actuators, controllers, as well as sensors which are utilized for closed loop systems. The data from the sensors is being processed by the controllers and gives control signals,