MECHATRONICS BOOK SERIES

CONTROL AND INTELLIGENT SYSTEMS

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Abiodun Musa Aibinu
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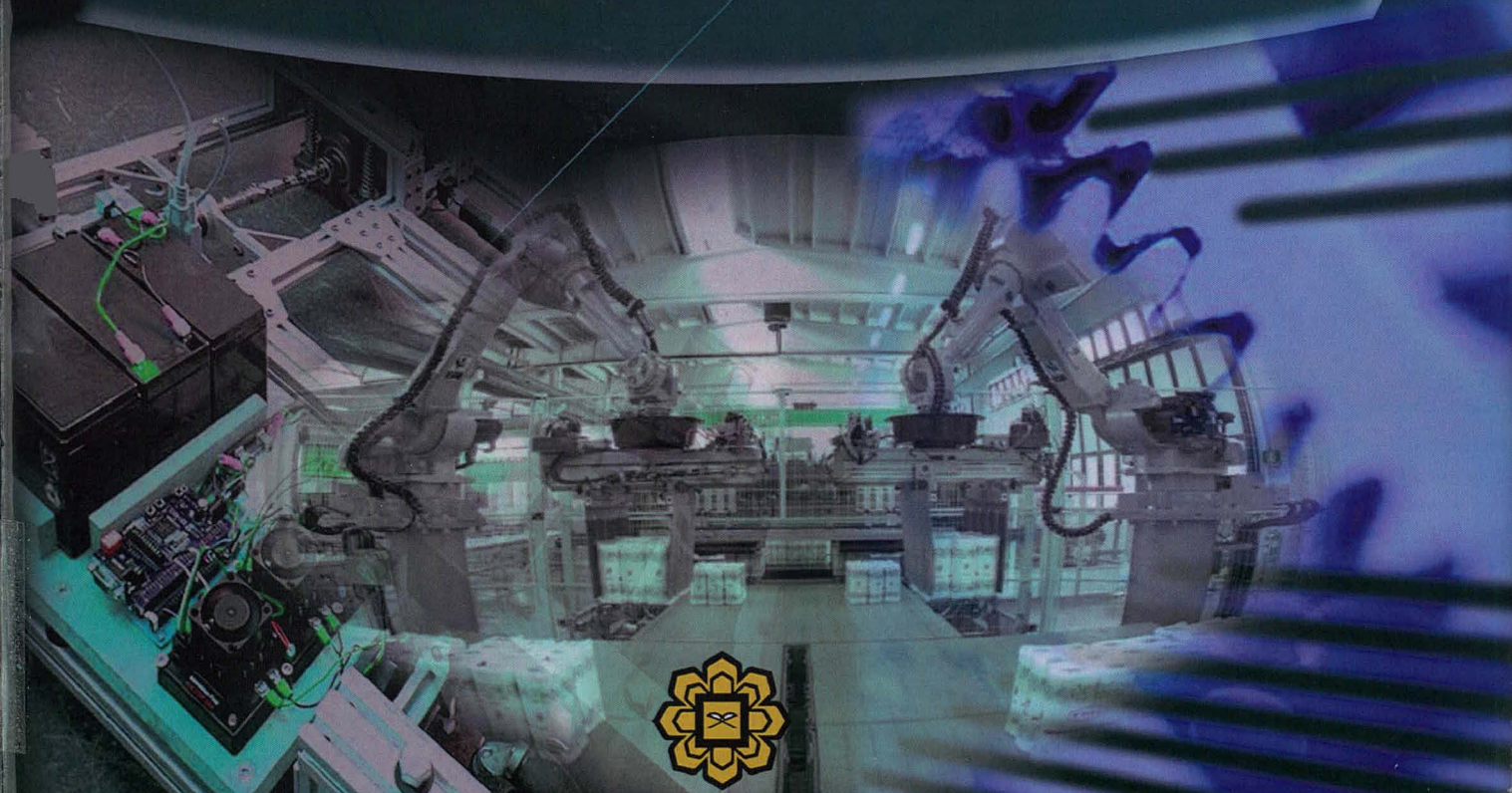

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Chapter 36
Hajj Crowd Simulation Based on Intelligent Agent

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6.1 Introduction

Hajj ritual is one of Islam pillars that is obligatory for each Muslim who are able (*istitho'ah*). This ability is evaluated based on hajj expenses, health, safety, and also knowledge about how to perform Hajj (*manasik*) [1]. Ministry of Hajj, Kingdom of Saudi Arabia reported that every year more than two million Muslim men and women from over a hundred countries gather in Mecca to undertake the Hajj pilgrimage with the tendency of growing up in number year by year. As mentioned in [2], the impact of Hajj is not only to improve the quality of relationship with Allah (*hablumminallah*) but also relationship with other human being (*hablumminannaas*). Furthermore, it is not only to improve the relationship between Muslim but also to increase tolerance with other non-Muslim fellow. Figure 36.1 illustrates the stages of Hajj ritual which consists of *thawaf*, *sa'i*, and *jumrah*.

Many researches have been done on hajj crowd simulation. The purpose of the previous simulation is to simulate the fluidity of the Hajj ritual. In 1990, Al-Gadhi and Mahmassani [3] studied on how to model the crowd behavior and movement on Hajj ritual based on fluid particle. Al-Zahrani and Matbouli [4] with the same approach have done simulation using SimWalk to control the crowd especially during *thawaf* ritual.

To best model the crowd, intelligent agent can be utilized as it enables each character in the crowd to have different goals and different behaviors which reflects the real world [5]. To realistically model the real world, the agent model not only must have the capability to make decision, but also must have location- specific capability [6]. Kim *et. al* [7] stated that individual or a group of pilgrims can be implemented as agents which have the capabilities to sense, think, and act. These capabilities enable more realistic human behavior and crowd model [8].

The objective of this chapter is to develop hajj crowd simulation based on intelligent agent so that it can perform more natural and more complex behavior compared to the one based on fluid particle. Moreover, the developed system can be used for educational purposes (*edugame*) to improve Muslim knowledge about hajj ritual. Lastly, the developed framework can also be used for other crowd simulation because of the existence of reusable components or objects.