Jeong Jin Kang
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Advanced and Applied Convergence Letters AACL 03

Advanced and Applied Convergence & Advanced Culture Technology

2nd International Symposium, ISAAC 2014
in conjunction with ICACT 2014
Jeju, Korea, November 2014
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Implementation of Stochastic Based State Diagram for Embedded Software System

So Young Moon*, Byungkook Jeon**, Jae Hyub Lee***, R. Young Chul Kim*

*SE Lab., Department of Computer and Information Communication, Hongik University, Sejong Campus, 339-701, Korea
e-mail : {msy, bob}@selab.hongik.ac.kr
**Dept. of IT Eng., Gangneung-Wonju Nat'l University, Korea
jeonbk@gwnu.ac.kr
***Dept. Of Computer Division, Koreatech, Korea
jae@koreatech.ac.kr

Abstract

Most embedded software systems are built into hardware systems. A state diagram is one method to model a reactive system. But general state diagram can nor solve some problems that caused by diverse state patterns designed if-else, switch-case of complex embedded system without built in advance [1]. Also for correctness of models, we implement a tool based on our stochastic based state diagram for embedded systems, which extend the state diagram of dynamic diagram in UML x.x for the embedded environment.

Keywords: *Embedded Software System, State Diagram, Concurrency, Stochastic.*

1. Introduction

Embedded software is a type of software that is built into hardware systems. This software is typically designed to perform and control a specific function. It is built in systems like cellular phones, televisions, planes, elevators, cars, robots, etc. Embedded software operates a lot of sensors in a car, and controls flight control systems, navigation system in an UAV (Unmanned aerial vehicle). Embedded system such as nuclear power generations, aircraft controls, missiles needs to guarantee high quality reliability because incorrect operation or suspend working causes critical problems. The classification system of embedded system model in "Modeling Embedded Systems and SoCs" of Axel Jantsch [2], a system is widely classified a static system and a dynamic system, and a dynamic part has a bigger meaning in the embedded system. The dynamic part is sorted by time-invariant, non-linear, discrete state, discrete time, and time driven. The time driven is classified to non-deterministic, stochastic, and deterministic. It is possible to implement other parts except the stochastic part.

In this paper, we review Mealy machine and Moore machine for modeling stochastic states of embedded software systems. To solve some problems that caused by applying variety of state patterns designed if-else, switch-case of complex embedded system before implementation in advance, we suggest a stochastic based state diagram for embedded systems for correctness of models.

2. Related Work

2.1 Mealy Machine

A state machine determines its outputs from a present state condition and an input value. In theory of computation, G. H. Mealy showed Mealy machine in "A Method for Synthesizing Sequential Circuits". It is

J.J. Kang et al. (Eds.): ISAAC 2014 & ICACT 2014, AACL 03, pp. 160~162, 2014
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a finite state machine from the present state condition and the input value. And also it means that the state diagram includes input/output signals for a transition.

<Formal definition>

Mealy machine is consist of six elements such as S, S0, $\sum$, $\wedge$, T, G.

- A finite set of states S.
- A start state S0 which is an element of S
- A finite set called the input alphabet $\sum$
- A finite set called the output alphabet $\wedge$
- A transition function $T : S \times \sum$
- An output function $G : S \times \sum \rightarrow \wedge$

2.2 Moore Machine

An output of Moore's finite state machine is only determined by the present state. It doesn't include the transition. In theory of computation, the output of Moore machine is only determined by the present state condition that is called by finite state automata. The state diagram for Moore machine includes the output signal about each state. Moore machine is introduced in "Gedanken-experiments on Sequential Machines" of Edward F. Moore who is leader of state machine[4].

<Formal definition>

Moore machine is consist of six elements such as S, S0, $\sum$, $\wedge$, T, G.

- A finite set of states S.
- A start state S0 which is an element of S
- A finite set called the input alphabet $\sum$
- A finite set called the output alphabet $\wedge$
- A transition function $T : S \times \sum \rightarrow S$
- An output function $G : S \rightarrow \wedge$'

The method of Mealy and Moore equals mathematically. However in general Moore machine requires more states to model same systems because Mealy uses another transition in the same state, and performs a different action. But Moore should use the different state in order to express a condition into being carried out another action [2].

3. Our Stochastic Tool based on Stochastic Based State Diagram

General stochastic process means a collection of random variables; this is often used to represent the evolution of some random value, or system, over time [5]. The method of Mealy, Moore, and Harel is impossible to model a state with stochastic meaning about a time. In this paper, for this kind of problems, we suggest the stochastic based state diagram which included a variety of state patterns designed if-else, switch-case, and and/or notations with probability to represent diverse behavioral changes of complex embedded system .

We make one example to explain the wiper rain sensors of the mobile car based on a stochastic system with our tool. The main functions of rain sensors work on sensing the amount of rain to move a proper speed of wipers, and also stop the wiper without raining. If the rain falls down the surface of the car wind screen, we represent the state diagram to work the behaviors of the car wiper based on unpredictable situation in figure 1.

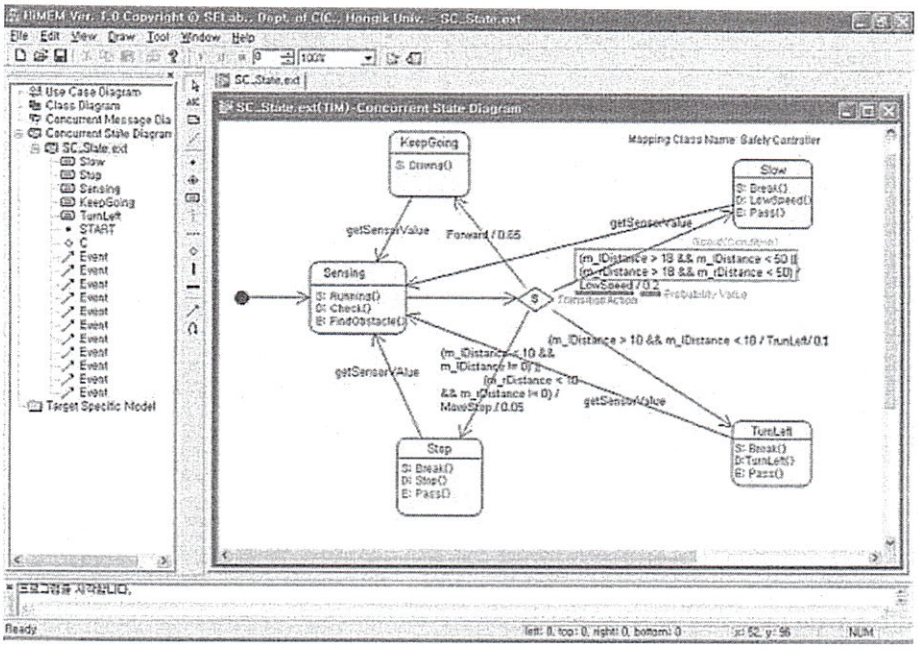

Figure 1. Stochastic based State Diagram for Car Wiper

4. Conclusion

In this paper, we analyze variety state of complex embedded system such as single, deterministic, non-deterministic, and concurrency through the state diagram which is the best method for reactive systems. However it reaches the limit to an event and time driven area according to stochastic states. We suggest the stochastic based state diagram for this problem. With this diagram, we make sure to keep the correctness with modeling validation and simulation for exactly working the embedded system.

Acknowledgement

This work was supported by the IT R&D Program of MKE/KEIT [10035708, "The Development of CPS (Cyber-Physical Systems) Core Technologies for High Confidential Autonomic Control Software"] and Basic Science Research Program through the National Research Foundation of Korea (NRF) funded by the Ministry of Education (NRF-2013R1A1A2011601)

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ISSN 2288-6060

Advanced and Applied Convergence Letters

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