

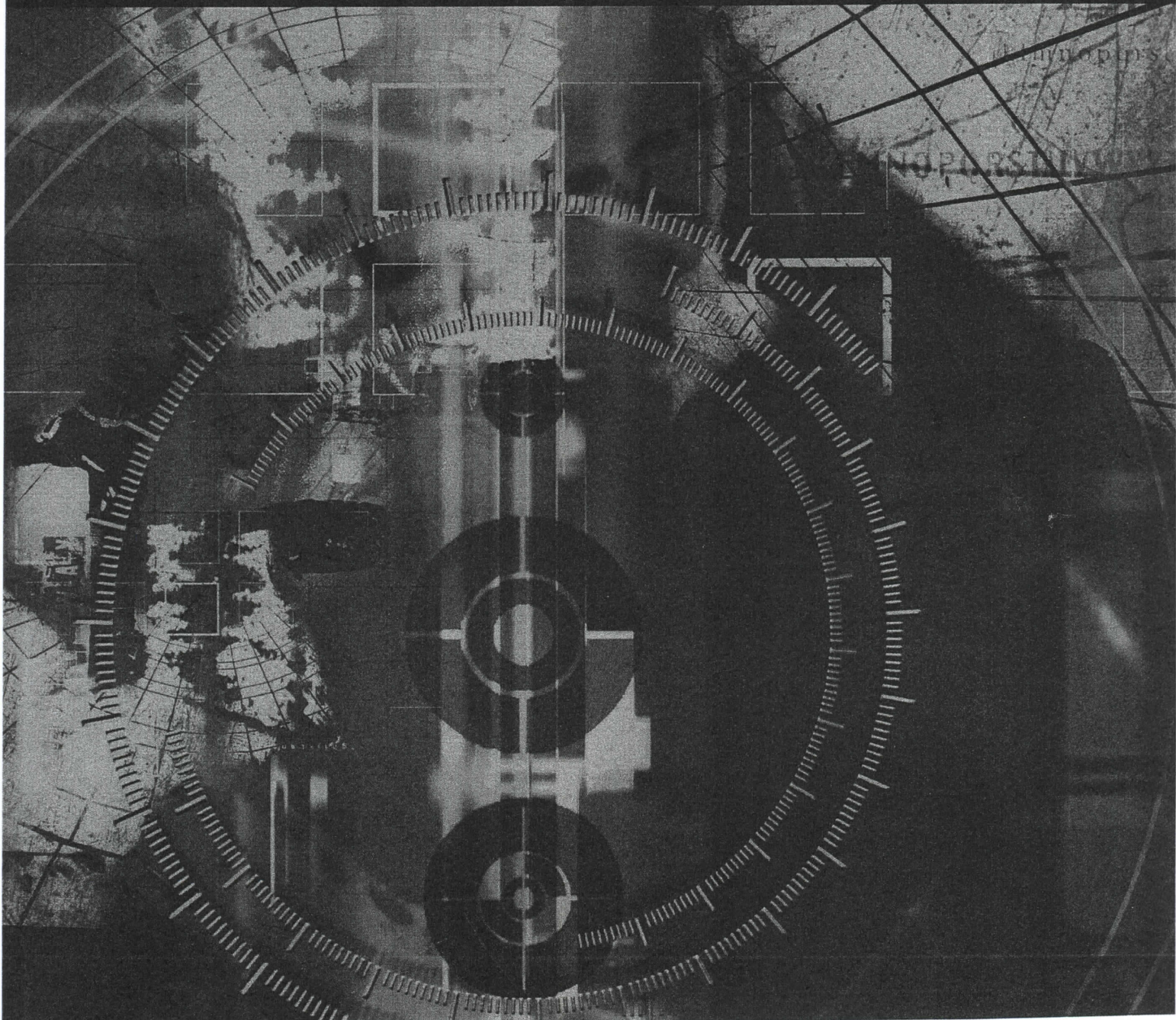


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Stochastic Design Tool based on Extended State Diagram for Reactive Software System

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Abstract

Most embedded software systems are built into hardware dependent systems. For modeling them, we use a state diagram as one of modeling tools for one method to model a reactive and real time system. But most state diagrams cannot model some particular random process problems that caused by diverse state patterns such as if-else, switch-case of complex embedded system without built in advance [1]. So for correctly designing random models, we develop *Stochastic Design Tool* based on our stochastic based state diagram for embedded systems [1], which extended the state diagram of dynamic diagrams in UMLx.x for the embedded & reactive environment. To show correctly modeling a particular system, we use our stochastic based state diagram design tool for correctly modeling diverse reactions on Javelin robot situations in crossroads.

Key Words: Embedded Software System, State Diagram, Stochastic based State Diagram

1. Introduction

Embedded & reactive software is a type of software that is built into hardware systems. This software is typically designed to perform and control a specific random function. It is built in systems like cellular phones, televisions, planes, elevators, cars, and robots, etc. Embedded software operates a lot of sensors in a moving vehicle car, and controls flight control systems, navigation system in an UAV (Unmanned aerial vehicle). Reactive & Embedded systems such as nuclear power generations, aircraft controls, and missiles need to be guaranteed high quality reliability because incorrect operation or suspend working causes critical problems. On 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 [1].

In this paper, 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 suggested a stochastic based state diagram for embedded systems for correctness of models [1]. In chapter 2&3, we explain a stochastic based stated diagram tool and show four cases in stochastic environment.

2. 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 [3]. The method of Mealy, Moore [4], 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 [1].

Non-deterministic model and stochastic model is pretty similar. Non-deterministic action is that a vehicle robot cannot decide doing either one action or other action without additional information. Otherwise, stochastic model may select non-deterministic action through statistical values already collected by nature observation. It deals with stochastic based state diagram and extended state diagram.

Various State Transitions

We describe the different types of the state diagram based on the transition. \diamond
Notation on the transition is added for modeling stochastic based state diagram.

Elements for Probabilistic Events Expression

A transition includes an event, a guard condition, and an action. We add probabilistic value to them when stochastic environment is modeled. So we describe a transition like Fig. 1.

Stochastic based state diagram is consists of five elements such as Σ , S, g, s0, F.

Σ : A finite set called the input alphabet

S: A finite set of states

g: A transition function $g: S \times \Sigma \rightarrow \mathcal{F}(\mathcal{E})$ where \mathcal{F} is a random function

$S = \mathcal{F}(\mathcal{E}, Gc)$ and $\mathcal{E} \subseteq E$

E is a set of event

s0 : Initial state, $s0 \in S$

F: A set of final state, $F \subseteq S$

In general state diagram, a trigger of transition has E(Events), C(Conditions), and A(Actions). However, it consists of four elements such as [E/Gc/A/Pw] on the transition of stochastic based state diagram.

E: Event
A: Action

Gc: Guard condition
Pw: Probabilistic weight value

For example, when a moving vehicle drives into a parking station, if no parking lot, parking system makes a reject alarm to it. In other case, the vehicle comes into the parking station. So we made that the transition includes an event, a guard condition, an action, and a probabilistic weight value.

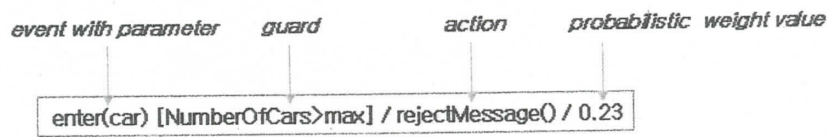


Fig. 1. Information on Transition for stochastic based state diagram

3. Our Stochastic Design Tool based on Stochastic Based State Diagram

We developed a design tool for stochastic based state diagram like Fig.2. [1], which included with some functions in Table 1.

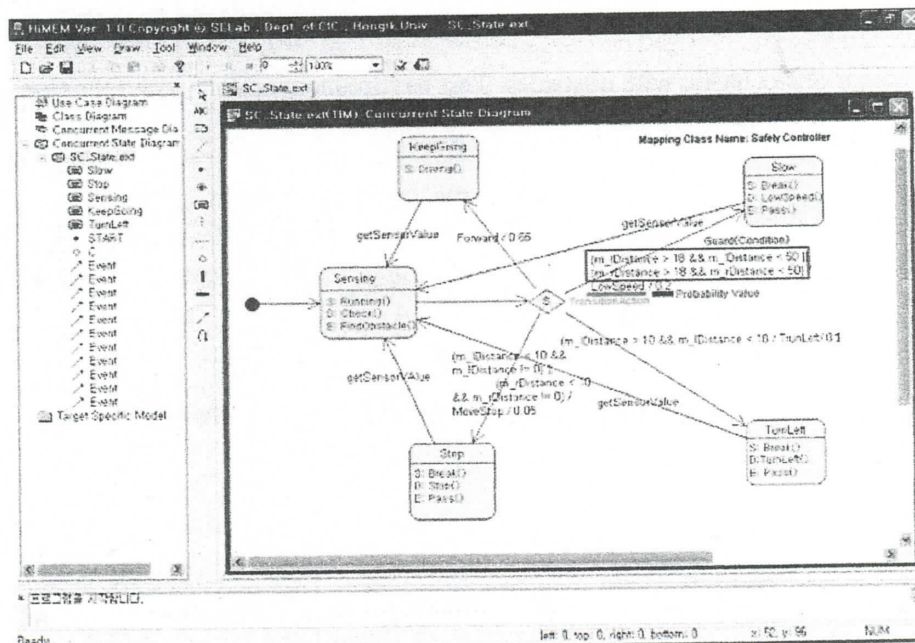

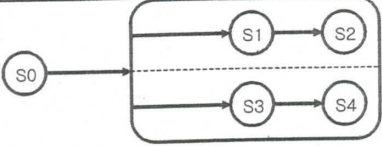
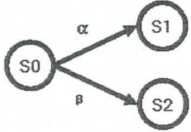
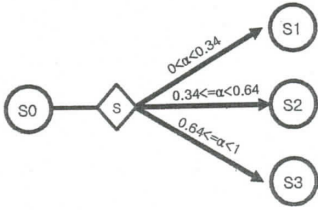
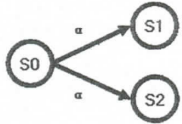


Fig. 2. Stochastic based State Diagram for Javelin in crossroad

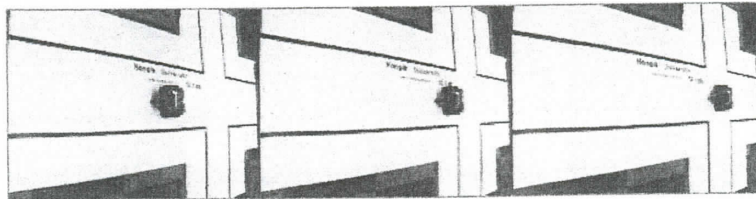
Table 1. Type and Description for State Diagram [5]

Description	Example for State Diagram	Description	Example for State Diagram
Single: simply transit to next state		Concurrency: transit to more than two states, when occurs thread	
Deterministic: transit to definite state		Stochastic: similar to non-deterministic, but it includes at least one output is random	
Non-deterministic: transit to next state randomly			

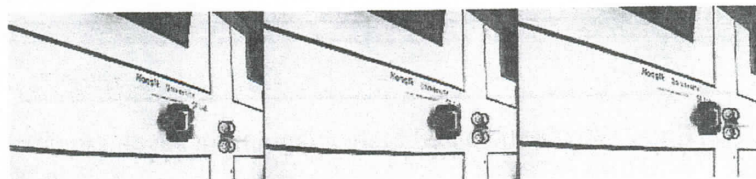
4. Case Study

Auto parking system and ESC (Electronic Stability Control) are developed and more improved for convenience and safety of driver in automotive industries. In these times most of car is built in ESC essentially. ESC is a stability control system which is when a driver sudden turns round with a steering wheel, it protects that car is overturned and car is derailed. We made some test cases for that kind of situation. A Javelin robot will be a car which is built with ultrasonic sensor. We will simulate four cases with Javelin which will get an environment of stochastic with obstacles. Test environment sets up with four cases.

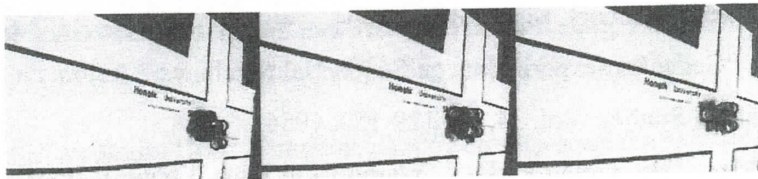
Case 1: no obstacle, car move forward.



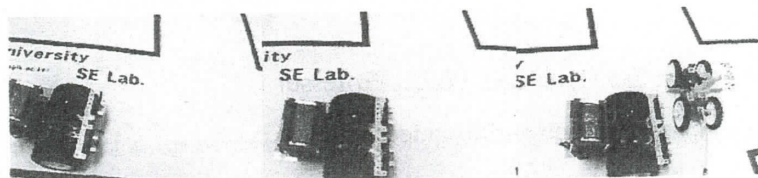
Case 2: when distance of obstacle and car is between 18cm and 50cm, car move slowly.



Case 3: when distance of obstacle and car is between 10cm and 18cm, car turn left sharply.



Case 4: when distance of obstacle and car is less than 10cm, car suddenly stop.



5. Conclusion

In this paper, we analyze variety state of complex embedded system. 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. We show to prove four stochastic cases with our design tool and Javelin robot. But we don't prove elements for probabilistic events expression with mathematic expression in this paper. And also our stochastic based state diagram tool doesn't generate a full source code. We should prove and generate full source code as future works.

6. Acknowledgments

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