Finite State Machines

Nimit Singhania

December 1, 2022

1 Introduction

Finite State Machine or simply State Machines are one of the most simplest computational models. A finite state machine consists of a set of states that a system can be in during the course of its operation. There are transition actions defined that transition the system from one state and go to the other state. The transitions can be defined over specific alphabet (used to define regular languages) or certain actions by agents or simply a time interval (as done in timed automata). These simple formalism is very useful to model and represent extensive phenomenan, both man-made and natural. The idea is very simple, the system starts in a particular state and transitions to another after a short time-interval or upon an action of an agent. The system can run continuously or terminate after a final state is reached. Once the final state is reached, the operation can be determined a failure or success depending on whether the final state is the desired state. There are many uses of finite state machines that we briefly describe below.

2 Example

To understand a finite state machine, the best example would be the household washer. The washer has multiple stages of operation: pre-wash, wash, spin, and shutdown. The washer starts with the prewash state, runs the stage for a fixed duration depending on the load-setting and moves to the next stage after a short interval. Similarly, the washer transitions from wash to spin and from spin to shutdown. The operation of finite state machine is simply defined by this example. A more elaborate example is one where the system transitions to another state on a certain action of an agent or an event. For example, the door bell starts ringing when someone presses the bell. Or the fire-alarm goes off when the amount of smoke in the room is higher than desired. These are also simple examples of finite state machines.

3 Application of finite state machines

The simplest application of finite state machines is in building models of complex systems that are then used for analysis like the HVAC system in buildings, the weather pattern of a place etc. By representing the system using a finite state machine, we can easily analyze the system and make predictions about the weather forecast for next few days or the estimated energy consumption over the next month. Some systems can naturally be represented via finite state machines, while others can only be approximately represented leaving some room for error.

Finite state machine is often used in designing controllers in real-world systems like boilers where complex reactions take place, and automate the processes using digital control. The controllers often assume a finite state representation of the real-world system, thereby making it simple to design the controller and verify its functionality in different states of the plant model for which the controller is designed.

They have application in computer science as well where a class of regular languages can be represented by a finite state machine that transitions on seeing a token or an alphabet of the language. The words in the language are defined by those where the finite state machine ends in an accepting final state. These are very useful to represent compact acceptors for different types of language inputs, and are popularly used in lexers (compilers), address sanitizers (web security) etc.

4 Conclusion

Finite State Machine is the simplest yet most useful computational system with applications in various domains. They can be used to model complex systems and define controllers for these systems. Further, they are useful to define compact acceptors for the class of regular languages which is widely used in the field of computer science for specifying different types of inputs. Different variants of finite state automata include timed automata (where the transitions occur after a certain time duration), Markov chains and decision processes (where the transitions are probabilistic), and finite transducers (where each transition is accompanied with a finite output).

5 References

1. Introduction to the Theory of Computation. M. Sipser. Third Edition.
2. https://en.wikipedia.org/wiki/Finite-state_machine