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Implementing a hybrid methodology for the design of an Embedded System

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Abstract— This paper described a hybrid methodology that can be deployed in the development of an intelligent critical sensitive system. To obtain this methodology, we interfaced the internationally accepted Structured System Analysis and Design Methodology (SSADM) and the Fuzzy Based Design paradigm. The SSADM was deployed for the systems study and preliminary design while the Fuzzy Based Design Methodology was deployed as the paradigm for an alternative design applied in developing both linear and non-linear systems for embedded control. The resulting methodology was successfully deployed to implement an intelligent traffic control system for a typical '+' in an Eastern Nigerian city. The work demonstrated that embedded systems required a hybrid methodology because in addition to the specialized design paradigm, there would be a need for a detailed study of the systems current operating environments

Index Terms—**Artificial Intellegence, Hybrid System, Metheddology, System Design.**

I. INTRODUCTION

Methodology was defined generally by [1] as a guideline for solving a problem, with specific components such as phases, tasks, methods, techniques and tools. The concept was further defined by the Merriam–Webster dictionary as the analysis of the principles of methods, rules, and postulates employed by a discipline [2]. Baskerville (1991) defined methodology as the systematic study of methods that are, can be, or have been applied within a discipline [3] and Katsicas, (2009) defined it as the study or description of methods [4]. A system development methodology refers to the framework that is used to structure, plan, and control the process of developing an information system. A wide variety of such frameworks have evolved over the years, each with its own recognized strengths and weaknesses. One system development methodology is not necessarily suitable for use by all projects [5]. In the early days of large scale information systems development many organizations used the COBOL programming language together with indexed sequential files to build systems for customer billing, payroll, stock control and a variety of other business areas. Frequently the results of this approach were systems which, on delivery, did not satisfy business requirements leading to a miss-match between system functionality and business requirements. This caused extensive maintenance requirements and thus an increase in the applications backlog. The response from the information systems community to these problems was the development of structured methodologies for Information System Engineering (ISE). The purpose of these methodologies seems to have been to (a) formalize the requirements elicitation process to reduce the chances of miss-understanding the requirements and (b) to introduce best practice techniques to the analysis and design process [6].

The nature of the problem at hand dictates the methodology (ies) to be adopted and sometimes it may be necessary to combine two or more in a hybrid approach. Looking at structured paradigms; there are some important considerations in critical-sensitive systems engineering that they do not address, and for which they may never really have been intended. For embedded systems in particular, structured methodologies cannot achieve an error-free design due to the complexities of the structural requirements of such system; thus, the need for a hybrid methodology is advocated. More so, an embedded system requires a hybrid methodology because in addition to the specialized design paradigm, there would be a need for a detailed study of the system's current operating environments.

This paper described our research experiences in defining a novel methodology for embedded system design. We interfaced the international accepted structured paradigm, the SSADM with the fuzzy logic process to obtain a hybrid methodology. This methodology was successfully deployed to build an intelligent traffic control system which utilized embedded sensors to check gridlocks at a popular '+' junction in an eastern Nigerian city. The rest of this paper is organized as follows: the methodologies deployed were described in section 2, the obtained results were discussed in section 3 and the simulation of the traffic system was presented in section 4. Section 5 finally concluded the paper.

II. MATERIALS AND METHODS

Two key methodologies were deployed in building the hybrid one in this work. The SSADM is a typical example of a structured waterfall model. The SSADM (in common with other structured methodologies) adopts a prescriptive approach to information systems development in that it specifies in advance the modules, stages and tasks which have to be carried out, the deliverables to be produced and furthermore the techniques used to produce the deliverables. SSADM adopts the Waterfall model of systems development, where each phase has to be completed and signed off before subsequent phases can begin. SSADM is one example of a structured methodologies, a variety of others such as the Structured Analysis, Design and Implementation of

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Information Systems, STRADIS [7], [8]; Yourdon Systems Method, YSM [9], the MERISE[8] the EUROMETHOD, which is a framework for integrating the existing European methodologies are widely used in Information system engineering (ISE) [8].

The SSADM is used in the analysis and design stages of systems development but it does not cover SITP issues or the construction, testing and implementation of software. SSADM has been used by the government in computing since its launch in 1981. It was commissioned by the CCTA (Central Computing and Telecommunications Agency) in a bid to standardize the many and varied IT projects being developed across government departments. The CCTA investigated a number of approaches before accepting a tender from Lear month & Burchett Management Systems to develop a method." (Eva, SSADM Version 4 - A Users Guide). Since 1981 SSADM is an open standard, i.e. it is freely available for use in industry and many companies offer support, training and Case tools for it [6].

The SSADM revolves around the use of three key techniques, namely Logical Data Modeling (LDM), Data Flow Modeling (DFM) and Entity/Event Modeling (EEM). LDM is the process of identifying, modeling and documenting the data requirements of a business information system. DFM involves identifying, modeling and documenting how data flows around a business information system while EEM is the process of identifying, modeling and documenting the business events which affect each entity and the sequence in which these events occur. The success of SSADM may lie in the fact that it does not rely on a single technique. Each of the three system models provides a different viewpoint of the same system, each of which are required to form a complete model of the system. Within SSADM each of the three techniques are cross reference against each other to ensure the completeness and accuracy of the complete model [7].

SSADM consists of 5 main modules, which are in turn broken down into a complex hierarchy of stages, steps and tasks namely: Feasibility Study, Requirements Analysis, Requirements Specification, Logical System Specification and Physical Design [10].

The term Fuzzy Logic seems to imply an imprecise methodology that is useful only when accuracy is not necessary or important but this impression is false about fuzzy logic. Fuzzy logic can address complex control problems, such as robotic arm movement, chemical or manufacturing process control, antiskid braking systems, or automobile transmission control with more precision and accuracy, in many cases, than traditional control techniques have.

Fuzzy logic is a methodology for expressing operational laws of a system in linguistic terms instead of mathematical equations. Many systems are too complex to model accurately, even with complex mathematical equations, but fuzzy logic's linguistic terms provide a useful method for defining the operational characteristics of such a system. These linguistic terms are most often expressed in the form of logical implications such as IF-THEN expressions [11]. Fuzzy logic can address complex control problems, such as robotic arm movement, chemical or manufacturing process control, antiskid braking systems, or automobile transmission control with more precision and accuracy, in many cases, than traditional control techniques have. Fuzzy logic is generally implemented in three phases: fuzzification, inference and defuzzification.The reasoning in fuzzy logic is similar to human reasoning. It allows for approximate values and inferences as well as incomplete or ambiguous data (fuzzy data) as opposed to only relying on crisp data (binary yes/no choices). Fuzzy logic is able to process incomplete data and provide approximate solutions to problems other methods find difficult to solve. Some of the terminologies used in fuzzy logic but not used in other methods are: very high, increasing, somewhat decreased, reasonable and very low [12].

III. RESULT DISCUSSION

A novel methodology was obtained in this work by interfacing the SSADM with another methodology based on the fuzzy logic paradigm. As shown in Figure 1 below, the systems study and preliminary design was carried out using the Structured System Analysis and Design Methodology and it replaced the first step of the Fuzzy Based Design Methodology as shown in the broken arc. The Fuzzy Logic-based methodology was chosen as the paradigm for an alternative design methodology; applied in developing both linear and non-linear systems for embedded control. Therefore, the physical and logical design phases of the SSADM were replaced by the two steps of the Fuzzy Logic-based methodology to complete the crossing of the two methodologies. This hybrid methodology is suitable for the design of intelligent and embedded systems. It was tested by deploying it in the design and implementation of an intelligent traffic lights control system. This traffic control system was implemented in a popular '+' junction in an Eastern Nigerian city. The hybrid methodology was appropriate because there was a need to examine the existing systems, classify the intersections as "Y" and "+" junction with the view of determining the major causes of traffic gridlock on the road junctions. There was also the need to design the traffic control system using fuzzy rules and simulation to implement an intelligent traffic control system that will eliminate logjam [13]. Figure 2 shows the overall internal context diagram for the intelligent traffic system as was implemented in [14].

To build the simulated version of the system in Figure 2 above, the Java SE 6 update 10 was deployed as a tool. This choice was based on the feature that the Java is the researchers' language of choice in developing applications that require higher performance [14]. The Java Virtual Machine, (JVM) provided support for multiple languages platforms and the Java SE 6 Update 10 provided an improved

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performance of Java2D graphics primitives on Windows, using Direct3D and hardware acceleration.

Figures 3 shows control centre for the simulation of the traffic control system. The system is highly graphical in nature. A number of pop-up and push-down menus were introduced in the implementation for ease of use (figure 3). Command buttons to display graphs showing waiting time of cars, Movement time of cars, car flow density and current

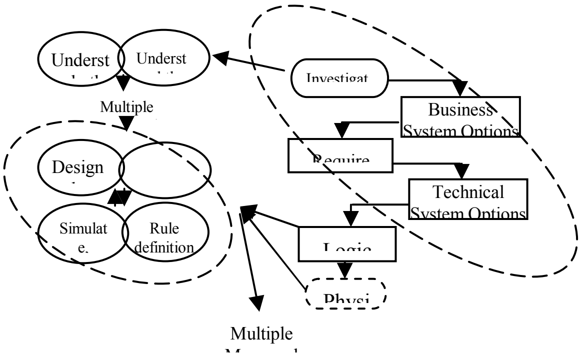

Fig 1. The hybrid methodology

Arrival/departure times were all embedded in the application's control centre. The views can be cascaded to show the control centre and any of the graphs at the same time. Two fuzzy input variables were chosen in the design to represent the quantities of the traffic on the arrival side (Arrival) and the quantity of traffic on the queuing side (Queue)

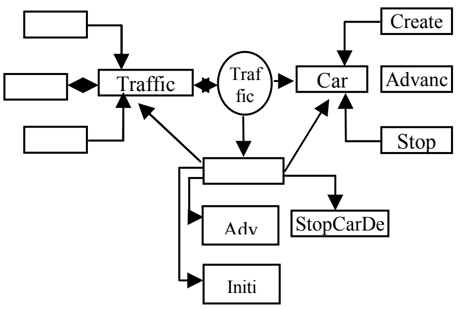

Fig 2 Overall internal context

The green side represented the arrival side while the red side is the queuing side. To vary the flow of traffic in the simulation according to real life situations; the density of flow of cars is set as required by clicking on the arrows on the sides of each lane [13].

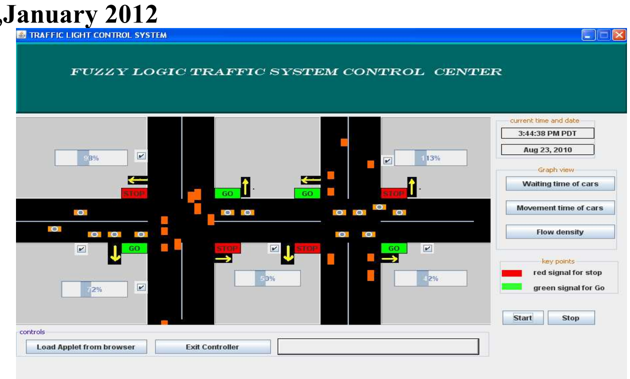

Fig. 3 .The simulated fuzzy logic traffic control system [13], [14]

IV. CONCLUSION

Methodology is generally a guideline for solving a problem, with specific components such as phases, tasks, methods, techniques and tools and its choice is sometimes made with respect to the problem at hand. It is our opinion in this paper that the structured paradigms may not be sufficient to address all the engineering concerns of critical-sensitive systems and that an embedded system requires a hybrid methodology because in addition to the specialized design paradigm, there would be a need for a detailed study of the systems current operating environments. We described our research experiences of defining a novel methodology for embedded system design in this work. We interfaced the international accepted structured paradigm, the SSADM with the fuzzy logic process to obtain a hybrid methodology. This methodology was successfully deployed to build an intelligent traffic control system which utilized embedded sensors to check gridlocks at a popular '+' junction in an eastern Nigerian city.

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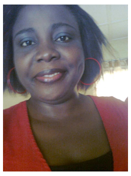

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