

## THE POTENTIAL OF SMART PROCESSING SYSTEMS IN THE BATTLEFIELD

John T. Economou, Antonios Tsourdos, Patrick C.K. Luk, Brian A. White<sup>1</sup>

**Abstract.** Computer systems in the past were significantly bulky and energy demanding. Nowadays, the computer systems have been considerably improved. Their reduced weight, volume, increased processing ability and robustness have allowed them to be included in the battlefield. Their use have allowed the inclusion of more sophisticated processing techniques which are not necessarily constrained to an “on” or “off” state. Smart processing methods and in particular the fuzzy logic methodology has allowed human knowledge in the form of simple rules together with several intermediate states to produce a range of states. The concept of smart or intelligent systems can simplify significantly the commanders’ decision making. This leads to faster response times from the commander and as a result could potentially increase survivability. This paper considers a smart tank concept in the battlefield. However, smart processing methods can be applied to a variety of battlefield systems. This paper outlines the basic principles of fuzzy processing systems as a complementary method of assisting the commanders’ decision making in the battlefield. The outline is followed by suggestions of how to model a particular tank sprocket electric drive sub-system within a tank. The smart processing method is not limited to the above example but intended to stimulate further application of the suggested method to a number of systems which require intelligent decision making in the areas of power and control.

### INTRODUCTION

Today’s battlefield has become more demanding than ever and now include urban and rural areas as the norm. Coordination within the modern military hierarchy must be precise and delivered securely and accurately to the receiving end. Tank commanders, for example, need to rely entirely on their crew’s performance, hardware reliability and energy resources in order to be successful in their mission. This paper is primarily focused on future tanks, which incorporate a dual-sprocket drive system, which is electrically driven. Such futuristic combat vehicles will consist of an internal combustion engine and electric drive arrangement together with their associated subsystems. The selective use of either the internal combustion engine or the battery pack results in great advantages, such as silent-mode operation, with the inevitable increase of the number of hardware subsystems and control strategies. It is therefore important to have the ability to perform extensive computer simulations which will allow the detail analysis of the vehicle’s motion associated with the main and auxiliary power supplies and control systems. In most cases there is an expert who can predict qualitatively the various systems behaviour for a variety of inputs. The expert’s knowledge can then be mapped to an intelligence-based method such as fuzzy logic [1]. Prior to explaining the fundamentals of this methodology we outline some basic facts.

In the early 1960s Lofti Zadeh firstly used the word ‘fuzzy’ after being inspired by the research of Lukasiewicz multivalued logic [2]. In the late 1980s the rapid development of the computer systems allowed the accelerated development and prototyping of real fuzzy logic products. Since then a variety of systems that employ fuzzy logic have emerged such as consumer appliances, cars, mobile robotics [3,4], radio graphical diagnosis, dental diagnosis, multilayer incinerators, glass melting furnaces, water purification processes, failure analysis, unmanned helicopter control, human characteristics characterisation, oral instruction car control, financial market prediction among others [5].

Boolean logic is the simplest form of fuzzy logic, which allows a given state to be described as ‘on’ or ‘off’, ‘true’ or ‘false’. Boolean logic has been the fundamental building block for the digital computer and it forms the basis of

Aristotelian logic. A real system such as an electrical drive system, for example, is not simply ‘off’ or ‘on’ but has intermediate grades which can allow the drive system to be ‘half on’ or ‘ $\frac{3}{4}$  on’ etc.

Smart systems [2] correspond to a family of methodologies which when combined result in an intelligent system. Fuzzy logic is the methodology, which is considered in more detail within this paper.

According to [5] the word ‘fuzzy’ denotes the characteristics of the phenomena that a fuzzy system theory describes and not the theory itself. Humans still today reason based on vague information and heuristics. The underlying motivation that triggered the rapid advancement of the fuzzy-logic theory is the need to represent and process imprecise concepts of information. Fuzzy systems are knowledge-based universal approximators. The fuzzy-logic methodology allows natural language statements to be used as means of describing, for example, a natural or man-made system. The methodology allows the systematic mapping of the user rules to basic equations. Depending on the input values a set of rules, at every time instant, will be active but at a different degree. The resulting fuzzy logic output will be a non-linear blend of the rule activation. For every time instant there must be at least one rule that is active in order to avoid singularities. The fuzzy logic rules can then be simulated on a digital computer and allow detailed predictions to be studied prior to prototyping, which reduces the risk of damaging the real system for extreme testing conditions.

According to [2] “The fuzzy principle states that everything is a matter of degree”. A typical example is when we add  $2+2=4$  which implies that two and two when added result to a membership function called ‘4’. As a result the  $2+2$  belongs 100% to the membership function ‘4’. However, when we add,  $2+1.8=3.8$  the result belongs to the membership function ‘4’ but to a degree which in this case according to Figure 1 has an 80% membership to ‘4’.

### CASE STUDY—AN ELECTRIC DRIVE MOTION PREDICTION

Future tank systems will rely even more on electrical drive systems for their motion. It is therefore necessary to have the

<sup>1</sup> Department of Aerospace, Power & Sensors, Cranfield University, Shrivenham, SN6 8LA, Swindon, United Kingdom.