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A Study on Soft Computing Methods For Dependable Cyber-Physical Systems

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Abstract: Using the computer intelligence, cyber-physical systems developed a way for manipulation of objects in globally. This is performed by communication between different computing elements and actuation. In the physical world, after the control, this sought is stopped by the disadvantages of contemporary communication networks. Soft computing is one of the emerging areas, in the fields of rough sets, probabilistic reasoning, evolutionary computation, neural networks and fuzzy systems. A review of soft computing methods is presented. In this paper also the dependability engineering foundations are explored.

1. Introduction

The human life is transformed by internet in various ways. It is one of the basic tool for operations of services, education, trade, manufacturing and business. No bridge exists in the physical world and there exists a gap between processing and exchange of information [19]. So, in the Cyber-Physical System (CPS) computational resources are integrated into a physical world [13]. This allows generation and usage of information in a better form. Physical entities orchestration is known as CPS in which computer components that are embedded are controlled and physical processes are monitored. This is performed by physical

processes and feedback loops [11]. Various examples are self-driving cars, home automation etc.

It is one of the popular engineering field [2]. The impact of CPS will be much more then It revolution [10]. CPS is offering unlimited benefits [17][15]. CPS exists in various ways as in industries, transportation system and utility networks such as services, manufacturing, healthcare, business etc. [8]. CPS is a vast field and some of its important applications are :

- More efficiently factories can be operated resulting to cutting of emissions of greenhouse.
- Pollution and traffic congestion can be minimized by autonomous vehicles and available awareness of obstacles.
- Universal healthcare can be provided by self-integrated health care systems.
- Smart grids can be used to for generating electrical power.
- Urban crime can be reduced by monitoring and intelligent surveillance leading to security of individuals [1].

Table I: Comparison of hard and soft computing

Attribute	Hard Computing	Soft Computing
Accuracy vs. Robustness	Accuracy mandatory	Robustness has priority
Logic	Binary logic	Multi-valued logic
Input data	Exact data required	Can tolerate imprecise data
Computation mode	Mostly Sequential	Supports parallelism
Precision of results	Precise answers	Approximate answers
Determinism	Deterministic	Non-deterministic

The methods of soft computing are working as enabler for making CPS systems adaptable and robust. The limitations of hard computing methods are overcome by soft computing methods [4]. In contrary to hard computing, soft computing works incomplete information, uncertainty and imprecision [4] [24]. The comparison is shown in Table 1. This research article briey explains the applications of soft computing in real life.

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2. Dependable CPS soft computing

2.1 Application domains dependable on CPS

The physical processes are integrated by CPS with networking and computation. Typical CPS system is depicted in Figure 1 with integration of computation, communication and control. They are also known as Sensor Actuator Networks (SANs), Distributed Control System

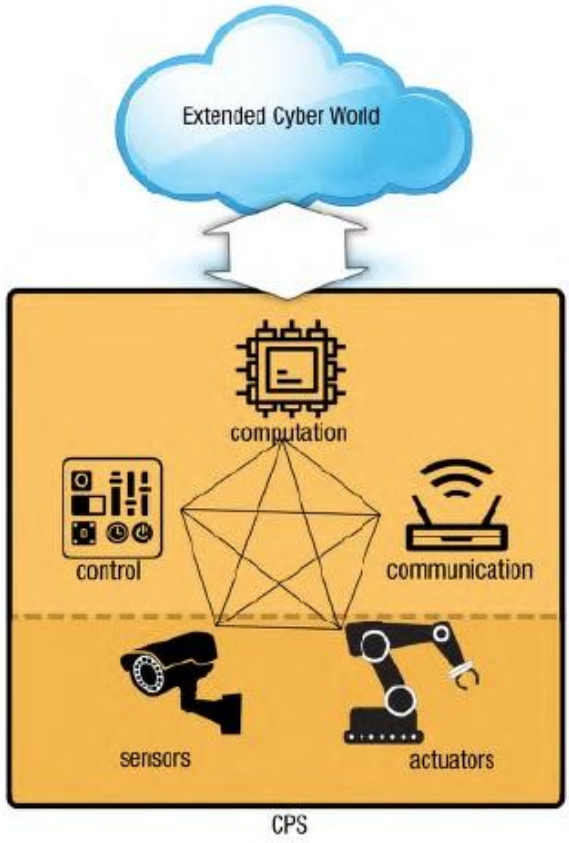

Figure 1: Structure of CPS

(DCS) and Networked Control System (NCS) [16]. The CPS can be modelled conceptually as temporally-integrated distributed control system. Multiple technologies are integrated as depicted in Figure 2.

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1. Smart Grids (Electrical Power Grid): It is geographically distributed entities collection that utilizes, regulate and generate power. A combined system of generation of power, distribution at large scale and automated management of power forms the CPS system [14].

2. Water Networks: It has an infrastructure that has utmost importance. It constitutes various sensing devices and there is increase in complexity for meeting the rising demands of industries and big cities [20].

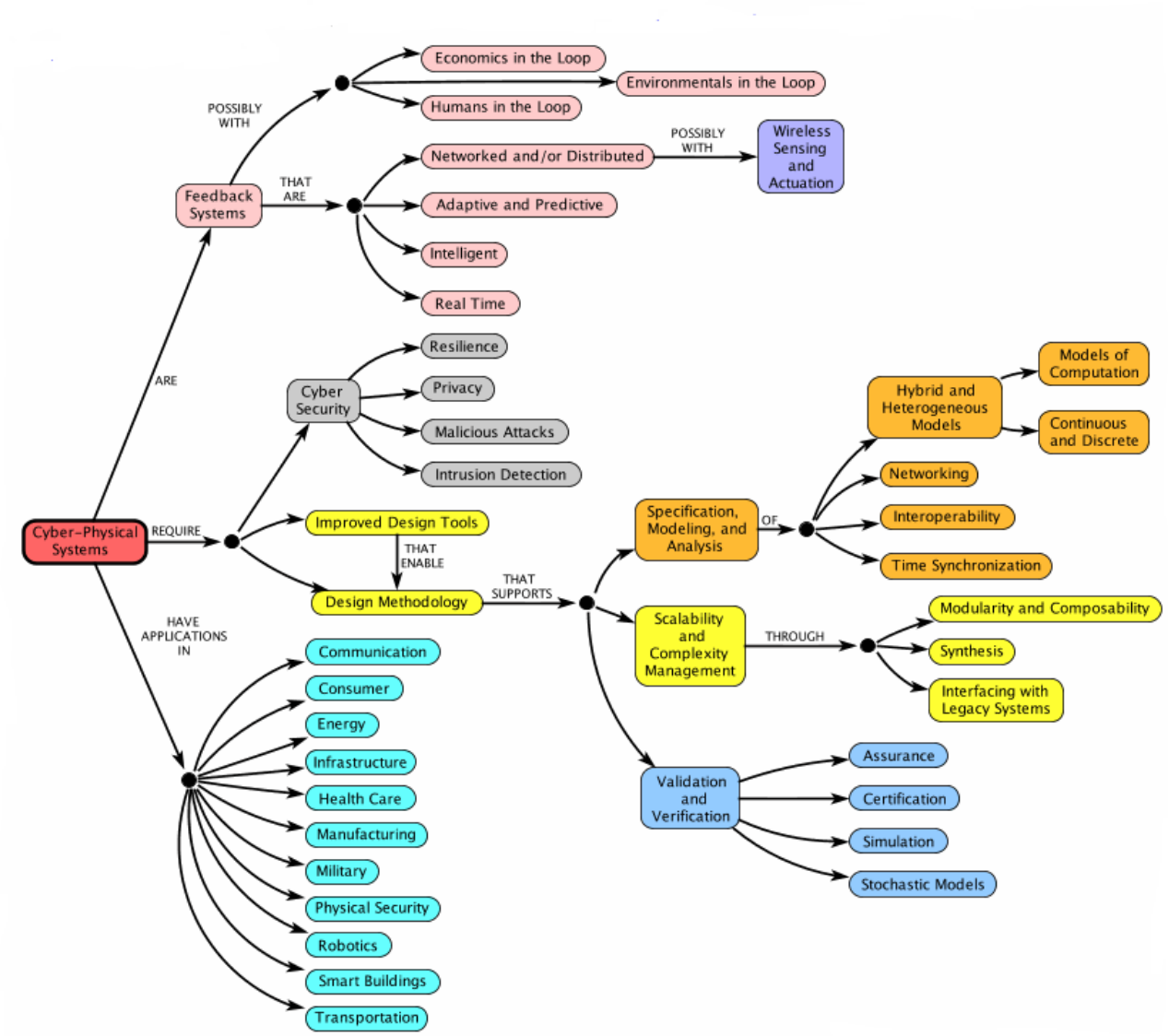

Figure 2: Cyber physical systems structure [11]

3. Industrial Automation: CPS provides a complete control on large faciltities of industries by usage of network architecture [23]. It results in various industrial profits for exibility of consumers [13].

4. Intelligent Transportation System (ITS): With the support of cloud, vehicular CPS that is context aware provides safety and convenience for drivers, passengers and pedestrians [21]. This minimizes the parking and traffic problems [18]. ITS failure have great environmental impacts and wastage of time [6].

5. Healthcare: CPS possess the interest for applications of healthcare. So health monitoring devices can be integrated such as cameras, actuators and sensors. Various architectures of CPS are proposed for enhancing the facilities of healthcare [12]. Integration of healthcare in CPS can make the personal patient information vulnerable to attacks [7].

3. Future work and open issues

The methods of soft computing are used for reliability of systems and performance optimisation. It aids the reliability and dependability for system analysis. It is also used for classification process and is able to get the extra information about system dependence and for approximation of reliability measures. The soft computing application for reconfiguration of failing system or viable action to be explored is still have pending investigation.

The Future work of CPS not addresses till date are:

1. Lack of analysis framework or unified modelling: The CPS design is challenging in hardware and physical systems term. For component level modelling of CPS , a unified framework is required [22].

2. Methodologies to design: CPS is being used on various kinds of applications. Various systems like power systems and smart homes are operated in various new ways [9]. New design technologies are required for integration with new systems thus avoiding disruption [5].

3. Security: The major problem in CPS is security insurance with coordination between physical and cyber components. They play an important role in networking system, power grid and healthcare. The emerging area of research is intrusion detection system (IDS) [3].

4. Conclusion

The applications of soft computing are discussed in this research article for dependability improvement and dependability analysis of CPS. The applicable scenarios and areas are summarized. Significant lack of literature exists in this area. Lot of future work is expected in the domain.

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