



A Comprehensive Survey Study on Current Trends and Challenges in Embedded Intelligence

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Abstract: Due to the advent of latest developments in information technology, many task-based resources have been developed. New business processes and latest automation programs have evolved. These systems have acquired the ability to perform and analyze its operations. Embedded Intelligence (EI) deals with such systems with auto-referential processes. This concept has become important for design and development of complex products and services. Integration of intelligence, sensors, wireless connectivity, and latest operating systems are involved in EI. Massively deployed embedded systems, its trust and security are also major concerns while analyzing challenges in EI. This article attempts to present various and recent trends, blend of components, and challenges involved in EI. This work also presents some possible solutions to the latest EI problems with the help of cyber physical systems and software engineering tools.

Keywords: Embedded Intelligence, Embedded Systems, Sensors, Massively Deployed Systems, Auto-Referential Process, Task-Based Resources, European Technology Platform (ETP), Product Driven Platform.

1 Introduction

Intelligence is considered to be highly structured concept which gives rise to variety of neural structures. These complex structures are referred in various types of intelligences. As the growth is gradual and monotonous, change in efficiency is considered to be as one of the basic task. This task is difficult to manage as value chains are becoming larger and more complex [1]. Here, companies are laying the foundations of technologies and solutions that may help economies to achieve a higher productivity. This platform is targeted to become the distributed neural network prosthetic that supports current economy, inducing a change in the way that production means are organized:

- A transition in development of products and various services to decentralized operations.
- A transition from hardware-oriented to software-oriented ecosystems.
- A transition to combined effort solutions from monopoly solutions.

The involvement of various generations in long term is required for new application technology. The objective involves participation of progressive and aggressive members in all aspects of the economy. A mind set for better transition in all aspects is considered to be one of the biggest challenge.

2 Related Works

The neural interconnections among intelligent quotient skills and other intelligences are involved in Neuroscience. It spreads among various domains such as inter and intra personal abilities, music, temporal, spatial and other allied areas. Table 1 below presents each of these types of intelligence and their features. The clash between intelligence quotient and machine intelligence is dependent

upon natural intelligence and common sense. Keeping in pace with the latest advancements in neuroscience and its allied domains, several proposals are made from previous understanding and semantics of concepts. The natural behavior and power of prediction are described by optimal scientific theories. Historical evidences collected from the past thirty years are considered as the strong platform for proposing the observations of natural intelligence.

To establish uninterrupted interactions among various service providers and capability of inter-operations are inevitable for System of Systems (SoS). General purpose platforms should cater to the efficient communication among various products from various service providers. Interoperability is the need of the hour in this context. Many technologies which are evolved recently are all addressing these issues during their developments. This is considered as the integral part of services from SoS.

The security and safety of mankind by cyber security is expected to be ensured. Products from various domains and safety of them are covered in cyber security. Here, decentralized document approaches may propose its significance in evolving flexible and secure environment in SoS for information sharing.

Capability of inter processes is very important feature for controlling diversity in SoS. This feature is used for fragmentation blocking and complexity reduction. Environment which addresses secure, efficient and effective systems, are involved in processes of SoS. They ensure orchestration capability, complexity and diversity of the system for its entire existence. Software tools caters efficient and cost-effective services along whole supply chain and existence of products.

As the development of latest computational techniques proved various opportunities of exploring its strength, these techniques have proved to be efficient recently. EI is one of these recent research domains which have many social and economic advantages. Ethical issues in machines are the latest trend among them. Along with implementing conscious and sub-conscious machines, semi-conscious machines are also evolved and are expected to do human activities. The proposed research work involves development of such algorithms and conducting statistical analysis on them.

Table 1. Intelligence Types and Their Features

Type	Components	Domains	Sub Domains
Inter Personal	Awareness, Regulations, Social Perception and Responsibilities, Leadership	Temporal, Time-Series	Event based and Context based
Mathematical (Logical)	Reasoning	Temporal	Equations, Axioms, Corollary
Linguistic	Speech, Reading, Writing, POS meaning	Temporal, Language context	Ontology based, Region based, Symbols or script based
Spatial	Cognition, visual arts, objects, Navigation	Frontal, Temporal	Cortex based
Musical	Perception, Emotions, Production	Subcortical, Temporal	Supplementary motor, Cortex
Kinaesthetic	Body parts movements, Symbolic movements	Frontal, Subcortical	Cortex based, Motor
Natural Flora Fauna	Living entities, pattern recognition, plant life science, animals	Subcortical, Temporal	Brain stem, mid-brain, stem, leaf, Thalamus

3 Types of Intelligence

Emotional intelligence is the ability to control human's wishes and to pause their accomplishments. It regulates the mood of an individual to isolate feeling from thinking. It caters to place an individual into another's views and to hope. Also, it includes a range of features like self-control, persistence, zeal and ability to motivate other humans. Emotional intelligence encompasses self-awareness, empathy, relationships, feelings, and motivation [2].

The parallel development of telecom technologies and digital evolutions have given huge scope and opportunities for online support and digital innovations. These digital developments encompasses Ultra-Dense Networks (UDN), artificial neural networks, 5G technologies, Software-Defined Networks (SDN), IoT and other allied areas. Interdependencies among these technologies have assisted in developing innovative methods for eye care during pandemic situations. The outcome shows the digital strategies that medical practitioners are developing. It also discusses methods that increasingly enter the clinical workflow and processes of ophthalmologists. Furthermore as countries around the world have initiated a series of escalating containment and mitigation measures during the COVID-19 pandemic, the delivery of eye care services globally has been significantly impacted. Challenges for validation and clinical implementation are studied, and recommendations on future directions are proposed [3].

The rapid development and implementation of smart and IoT based technologies have allowed for various opportunities in technological developments for different aspects of life. The objective of IoT methods are to simplify processes in various fields, to ensure a better efficiency of systems and finally to improve life quality. Sustainability has become a key issue for population where the dynamic development of IoT technologies is bringing different useful benefits, but this fast development must be carefully monitored and evaluated from an environmental point of view to limit the presence of harmful impacts and ensure the smart utilization of limited global resources. Remarkable research works are essential in the previous sense to investigate the advantages and disadvantages of IoT technologies. The focus of the present researchers is towards key conference tracks such as Smart City, Energy/Environment, e-Health and Engineering Modeling. The research presented and discussed at the SpliTech2019 conference

helped to understand the complex and intertwined effects of IoT technologies on societies and their potential effects on sustainability in general. Various application areas of IoT technologies were discussed as well as the progress made. Four main topical areas are - IoT technologies in Sustainable Energy and Environment, IoT enabled Smart City, E-health – Ambient assisted living systems, and IoT technologies in Transportation and Low Carbon Products. The main outcomes of the review introductory article contributed to the better understanding of current technological progress in IoT application areas as well as the environmental implications linked with the increased application of IoT products [4].

An attempt has been made to recognize and examine the strength of spiritual intelligence. It is done along with positive attitude and interest in the dominant factors responsible for strengthening it. The study confirms that it is the intelligence that helps to fulfill the potentialities of the individuals' abilities through the non-cognitive virtues. This prepares them to solve the problems for life creatively and constructively in the environment. It helps in attaining the highest knowledge and wisdom. If the teachers enable to modify such kind of behavior patterns of individuals, then it is referred as spiritual intelligence. But recently, it suggests that spiritual intelligence is supportive to teachers and individuals in general for the betterment of the global society as a consciousness [5].

Intelligence of physical agents, such as human-made and biological ones, is not only enabled by their Computational Intelligence (CI) in their brain, but also by their Physical Intelligence (PI) encoded in their body. Therefore, it is essential to advance the PI of human-made agents as much as possible, in addition to their CI, to operate them in unstructured and complex real-world environments like the biological agents. This article gives a perspective on what PI paradigm is, when PI can be more significant and dominant in physical and biological agents at different length scales and how bioinspired and abstract PI methods can be created in agent bodies. PI paradigm aims to synergize and merge many research fields, such as mechanics, materials science, robotics, mechanical design, fluidics, active matter, biology, self-assembly and collective systems, to enable advanced PI capabilities in human-made agent bodies, comparable to the ones observed in biological organisms. Such capabilities would progress the future robots and other machines beyond what can be realized using the current frameworks [6]. Among the workers, communication skills plays an important role and helps in optimal time consumption in any defined and advanced computational tasks [7].

4 Design and Methods

To conduct a research study which is qualitatively and quantitatively optimal, emotional intelligence possess multiple case studies [8]. Emotional intelligence is an allied area of research under sentiment analysis. Category-based buckets are defined for individual emotions, and later computational methods classify the inputted documents suitably. BRAE algorithm was invented during 2015 by researchers in sentiment analysis. By incorporating the POS tagging rules of the considered language, researchers have found promising results in carrying out testing on several sample documents. In this study, methods and design of computational techniques are explored for the current technological needs. Some researchers focus on information while others focus on examination of relations among them. As all of us know that information is abundant and storage is essential, researchers have explored various techniques and methods to store them effectively and efficiently over cloud. Qualitative research focusses on design aspects [9]. The development of any computational method depends on the feedback of the users. Critical reviews and fine-tuning the quality if the product developed, are highly essential for the long durability of such software products. Study has revealed that rigorous evaluation of methods at every stage of the development helps in optimizing the time of development also [10]. So, suitable soft skills in association with computational techniques will help in the development of latest products. Vast volumes of sources of information and their storage is always a challenging stage in software development. Data storage and technology networks deals with such challenges and proposes advanced methods to store them. Cloud computing, grid computing, bulk storage of data in cheaper way are all proposed in the last decade [11]. The sampling of data is also essential to deal with during soft computing.

Artificial neural networks, Fuzzy techniques, Genetic algorithms and techniques which uses Heuristics are considered under soft computing. Bias in neural networks helps in fine-tuning the results obtained. Proper sampling of data and applying suitable computational technique plays a vital role in the success for any method. Researchers have found methods to customize the data into information and then to apply the developed methods. The developed system must be tested by considering unique training and test data sets. That means, both training and testing data sets should not be the same for critical review on methods developed. Later based on the feedback by the end users, the choice of the method will be finalized [12]. Among all types of cancer disease, Breast cancer is considered as one of the severe and dangerous disease. In Asian countries, majority of the patients are asymptomatic and they develop multiple complications during final stages. Computational methods to screen these cases at early stages and periodic monitoring is essential. Proper diagnosis and medication is still missing in several developing countries. However, researchers are exploring several approaches and proposing solutions to the local governments from past two decades. As compared to the earlier situations, current computational methods have proved to be effective and efficient, if diagnosed early [13].

5 Conclusion

By the combination of many technology domains, EI has evolved. Cyber-physical and embedded systems, IoT and secured system of systems, edge computing, embedded AI, embedded HPC, integration of platforms, and finally embedded software technologies and tools – are combined together for this evolution. Types of intelligence discussed in this paper are evident that the sophistication in life poses evolution of such intelligence in machines. This article presents the necessity of exploring embedded intelligence in ubiquitous computing. Ubiquitous or pervasive computing covers all possible domains of the society where computational techniques can be developed and applied for the sophistication of mankind. Automation of human common sense has evolved in the generation of artificial intelligence in machines. Similarly, automation of human intelligence gives rise to expert systems. As the development of research domains are endless, application of intelligence is also limitless. In almost all domains, we can experience the applications of embedded systems and its intelligence. Researchers are given a huge scope to explore more possibilities in embedded intelligence.

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