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Edge Intelligence: Architecture, Scope and Applications

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A B S T R A C T

Edge intelligence implements the edge devices with intelligence, Edge intelligence refers to the union of Edge computing and AI. It goals at achieving an optimized data processing and security for end users. In this paper, we present a in-depth and exhaustive study on edge intelligence. Here we also discussed the evolution edge Intelligence, How the idea proves to be a efficient and optimized one as compared to the centralized approaches .Here we discussed a in-depth study of the architecture, its various components and working. And discussed some of the major breakthroughs in the area along with the future scope and challenges in Edge AI.

Keywords: Edge Intelligence, AI, Edge Computing, Cloud Computing

1. Introduction

With the increase of huge amount of data produced day-by-day have increased the need to have a techniques to store and utilize the data produced. In the late 90's JohnMacCharty[1] proposed through a speech delivered at MIT that "computing can be sold like a utility, just like a water or electricity". That was a timely thought with a vision for the future, However as the technology was not that advanced at that time the idea could not get its life. Then the time passed, technology got advanced and in the year 1999 Salesforce.com for the first time provided public Software-As-A-Service[2]. And later on many organizations started providing cloud services[3] and the concept of cloud computing[3] started getting high attention among the business community and Researchers. The concept of cloud has high acceptance due to its-Low maintenance cost, Ease of Accessibility, Fault-tolerance etc., Similar to a coin having two sides Unlike the positives the concept of cloud has some negatives which include the need of having internet connectivity, latency related issues which includes bottleneck of request which could lead to delay in responses.Furthermore, cloud computing by and of itself was not the blend in all the applications. With the emergence of autonomous cars and IoT in business, there was a growing need to have local processing of information in order to enable faster responses. Here came the concept of Edge computing[4], The term "Edge" refers to the sensor node or computing node. And the edge computing here refers to the idea of bringing the computation and storage closer to the source of data. Edge computing has many advantages over the cloud computing which include reduced response time and optimized utilization of bandwidth and also in terms of providing enhanced security and privacy, Edge computation approaches follow a decentralized agile approach for processing and response which makes them fast and much more efficient than the counterpartsBut the manual interference for the edge computing tasks makes it a tedious task. Here arises the need of Intelligent Agents[5] which combines Edge computing and AI[6] for automating the dynamic, rapidly changing environment.

The pipeline of this paper includes the concept of Edge Intelligence, Its Architecture, some of the applications and research works, future scope of this technology and comparison of some of the works in Edge Intelligence in the coming sections.

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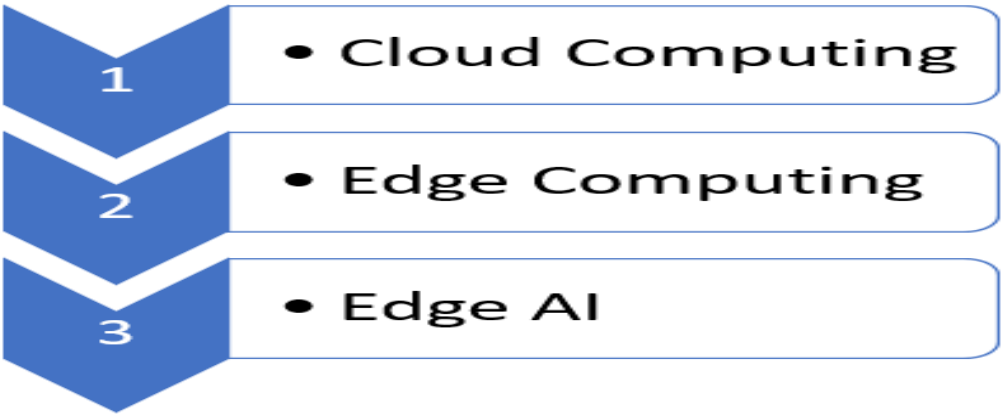

Fig 1: Evolution of Computation Models

2. Architecture Of Edge Intelligence

Edge Intelligence refers to the technology which introduces the property of intelligence to Edges devices by combining the Edge nodes with AI. The figure 2 refers to the block diagram of the Edge intelligence.

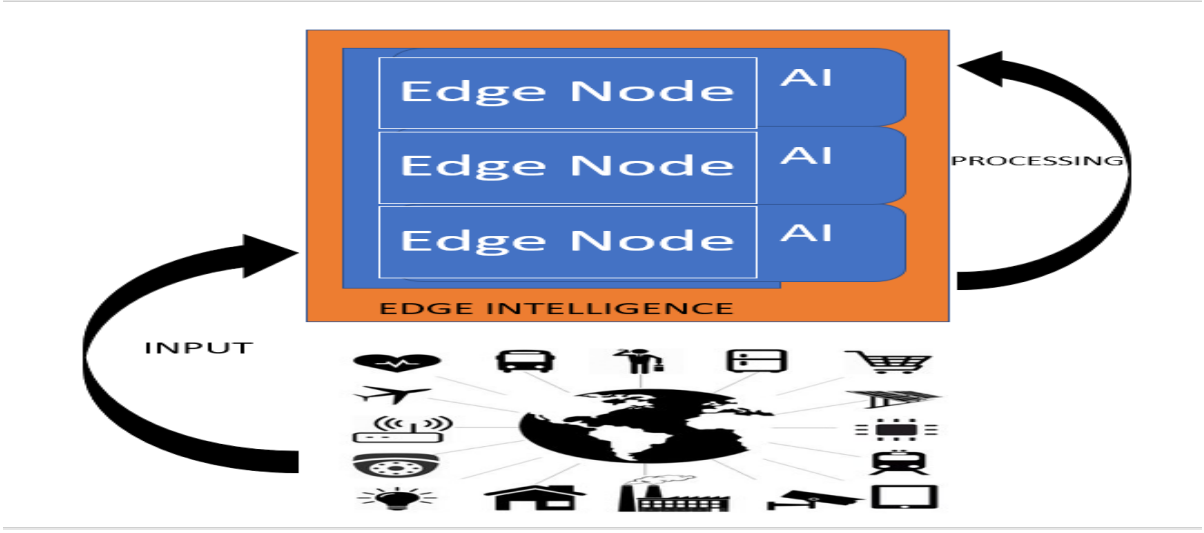

Fig2 : Block Diagram Showing Edge Intelligence

This figure illustrates the working of the Edge intelligent nodes. The idea introduced here is the edge nodes or the sensor nodes which are very close to the user proximity are trained with the AI algorithms, So here rather than doing the computation in global storage the locally, the nodes are enabled with intelligent components to make computational intensive and more efficient model.
Figure 3 shows a more detailed explanation of Edge Intelligence in terms of the components[7].The four components include:

1. Edge Caching[8]- It is considered as the initial block which gathers and stores the data from the environment or the IOT devices. It is placed nearer to the user proximity. Repeatedly accessed data in few KB are stored here due tothe constraints in the resources equipped with the edge nodes.

2. Edge Training[9]-This component of block includes a distributed learning approach that learns the most appropriate value for the weights and biases based on the input.

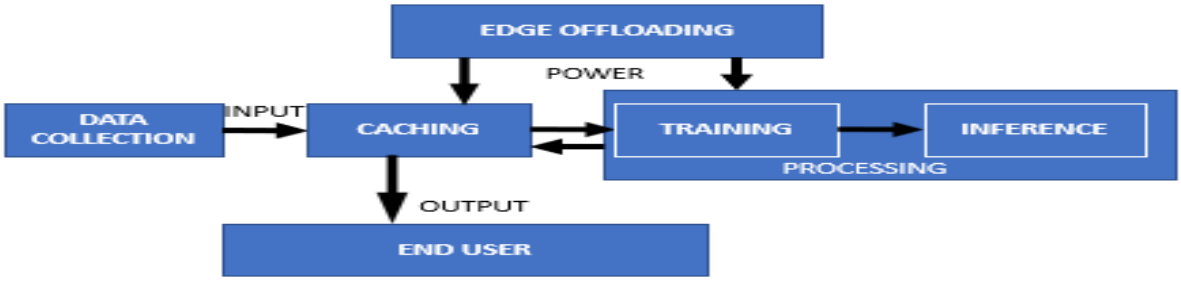

Fig3 : A more detailed Block Diagram of Edge computing

3.Edge Inference[10]-This component is responsible for inferring the insights from the test cases when fed to the trained model. It adapts to a forward pass which computes the final output for the edge device.

4.Edge Offloading[11]- Edge offloading here refers to leaving the pre-processing tasks in the edge device and moving the rest to the cloud for further processing which ultimately aims at reducing the data load over the edge devices.

Summarizing the Edge Intelligence components -The input data is collected by the Caching block which forwards to the processing block, Which after processing reinstate the processed value for the end user.

3. Application in Various Domain

This section deals with the comparison of the different implementation in different domains involving Edge intelligence. The domains are the following:Healthcare now-a days has become high growing industry, As the people have started becoming more conscious towards the health. Technological advancement in the domain has increased the reach of the facilities to a wide population. Edge Intelligence system has created its space over this domain. Some of the works include-Activity Recognition[12], Skin Cancer Recognition[13],Patient Monitoring [15], stress prediction and classification[14] and many more.The figure below shows a comparison

PAPER	IDEA	DOMAIN
[12]	Activity Recognition using Wearable Smart Sensors .Here for activity Recognition RNN model is employed.	Healthcare
[13]	Skin Cancer Recognition, Pre-trained CNN implemented on smartphone for skin-lesion classification	Healthcare
[14]	Paper discusses an approach for patient monitoring inside the home with ECG sensor and accelerometer on Wi-Fi	Healthcare
[15]	The paper discusses an approach of stress prediction and classification using the wearable sensors employed with Deep Learning Algorithms	Healthcare

Fig4: Edge Intelligence in various domain

The education system has evolved much. From the gurukul system to the modern online education has witnessed tremendous change in the sector. School Evaluation system[18] for evaluating the students in the sports domain using AI and Edge. More-ever , Edge intelligence has started creating its own space in every domain which extends to Smart devices, Agriculture, Retail etc., The figure below shows some of the applications.

EI Application	AI Basis	Commercial Products	Category
Video Analytics	CV	SenseTime SenseDLC SDK	Software
		HIKVISION iDS Smart Camera	Device
		Dell EMC Video Surveillance Solution	Platform
		Huawei Video Surveillance Solution	Platform
		Honeywell Video Surveillance Solution	Platform
Cognitive Assistance	CV, NLP, SR	Google Lens	Device
		Amazon Alexa	Software
		Microsoft Cortana	Software
		Apple Siri	Software
IIoT	CV, Robotics	Intel Industrial Automation	Platform
		IBM PMO	Platform
		Alibaba Cloud ET Industrial Brain	Platform
		Simens MindSphere	Platform
Smart Home	CV, NLP, SR, Robotics	Intel Smart Home Development Acceleration Platform	Platform
		Huawei Smart Home Solution	Platform
		Google Home Hub	Software
		Microsoft Home Hub	Software
Precision Agriculture	CV, Robotics	DJI Agriculture Drone	Device
		Intel Precision Agriculture Kit	Software
		KAA Smart Farming Solution	Software
Smart Retail	CV, NLP, SR, Robotics	Intel Smart Retail Solution	Platform
		Amazon Go	Infrastructure

Fig 5 : Various Realtime applications of Edge Intelligence[19]

4. Challenges and Future Scope

Besides having many advantages there are some challenges that are basically faced by the model includes-Poor data quality by the network providers is pulling back the enterprises to shift completely to edge, vulnerability to security is another concern, due to the decentralized approach adopted by the model there is a increased chances of being susceptible to cyber attacks and Limited Machine learning power added to the edge to make it efficient and light-weight might sometimes cause the system to compromise with its theoretical idea. However the world of Edge devices and Edge computing is beholding a notable attentiveness with new use cases. "The 2021 State of the Edge report by the Linux Foundation has estimated that the global market capitalization of edge computing infrastructure would be worth more than $800 billion by 2028"[20]. Enterprises are also deliberately financing in artificial intelligence technologies. The survey by McKinsey's conducted last year revealed that 50% of the global market have included AI in at least one business function. Most of the Enterprises are investing in technology advancements though digital transformation forward-looking new opportunities on fusing Edge computing and AI. More-ever, The rise in acceptance in Edge AI has also increased the interest of research community due to its attractive features like flexibility, faster processing computation, effective data storage to the near proximity to the end user and enabling smart devices which would support different industries.

4. Conclusion

In this paper, aim to present a thorough and exhaustive study of the literature in edge intelligence. Started with what edge intelligence is, How it evolved, comparison between cloud and edge methodologies, How AI plays a vital role in edge to make it intelligent. Discussed a block diagram and architecture of the Edge AI models with its working and the final section covered comparison of some of the major Edge AI breakthrough works. Moreover, the paper also discussed the future scope and challenges surrounding the Domain. Summarizing the era of intelligent Edges, it is only the tip of Iceberg. An explosive and wide range of works are waiting to be counted in this domain

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