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Artificial Intelligence in Smart Water Distribution

Shubham Sharma[1], Yogesh Mohan[2]
[1]*Research Scholar,* [2]*Assistant Professor, Department of Computer Science, Himachal Pradesh University, Shimla, India*

Abstract: ***This paper deals with the study of Trustworthy aspect of Artificial Intelligence (AI) which is known as Trustworthy Artificial Intelligence (TAI) and how it can be used to make a Water Distribution System (WDS) into Smart Water Distribution System (SWDS).***
The main premise of this paper is to conduct a literature review of Trustworthy Artificial Intelligence along with few notable contributions made by AI in making water distribution systems smart.
Keywords: Artificial Intelligence, Trustworthy Artificial Intelligence (TAI), Water Distribution System, Smart Water Distribution System, Fairness.

I. INTRODUCTION

With the advancement of all facets of technology [**1**], AI has come to the forefront in the recent times. From its applications in tools like ChatGPT, Google Bard, Amazon Comprehend and so on [**2**] [**3**] [**4**] to its applications in the field of healthcare like in diagnostics and so on [**5**] [**6**] [**7**]. AI has now become one of the most widely used applications of Data Science and Computer Science. In the most simple terms AI is an attempt made to make machines, i.e. usually devices relating to the field of computers and similar devices, act and make sound decisions like humans without any human intervention. This is achieved by using popular AI applications, namely, Deep Learning, Machine Learning (ML), Reinforcement Learning, Computer Vision, Natural language Processing, Robotics, Recommended Systems and Internet of Things [**8**] [**9**].
The main concern which is raised when conversations about AI are ignited is that whether or not using AI is safe, how can we ensure our safety and the safety of our data when we AI enabled systems. To mitigate this concern, the concept of Trustworthy Artificial Intelligence came into being.
Trustworthy Artificial Intelligence (TAI) is a term which describes an AI System which is lawful, ethically adherent and technically robust [**10**] [**11**]. The main premise to establish TAI was to build proverbial shield which would protect the users of AI from the major drawbacks and safety concerns.

II. TRUSTWORTHY ARTIFICIAL INTELLIGENCE

TAI as defined by High-Level Expert Group (HLEG) on Artificial Intelligence which was setup by the European Commission (EC) [**12**] states that, “Trustworthy AI has three components, which should be met throughout the system's entire life cycle: (1) it should be lawful, complying with all applicable laws and regulations (2) it should be ethical, ensuring adherence to ethical principles and values and (3) it should be robust, both from a technical and social perspective since, even with good intentions, AI systems can cause unintentional harm. Each component in itself is necessary but not sufficient for the achievement of Trustworthy AI. Ideally, all three components work in harmony and overlap in their operation. If, in practice, tensions arise between these components, society should endeavour to align them.”

In view of the above definition it can be interpreted that when the AI system is developed [**13**], it should be made sure that it is lawful, ethical and robust [**14**]. This all would ensure

1) *Privacy:* Meaning the data which is being used by the AI system is kept private,
2) *Robustness:* Meaning that AI is secure, reliable and can handle all real life exceptions with high accuracy,
3) *Explainable:* Meaning that there should be an explanation behind every decision and every step taken to reach at that decision,
4) *Fairness:* Meaning that AI system is free from any kind of biasness and
5) *Transparency:* Meaning that the users should be aware about at what points they are interacting with the AI systems [**15**].

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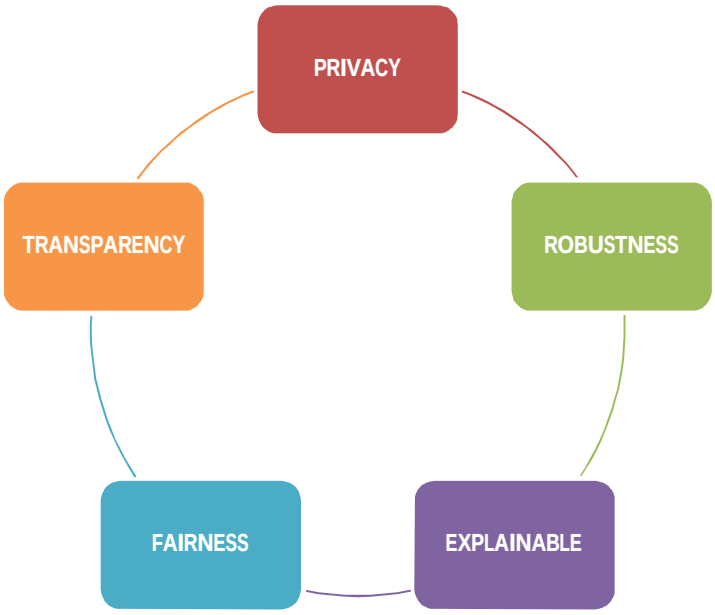


Figure 1:- Shows that an lawful, ethical and robust AI system will ensure the above mentioned qualities

As stated by the author in [**16**] a formal mechanism to systematise the parameters of trustworthiness needs to be established so as to make any given AI system, regardless of its field of application, can be made trustworthy. This in turn would promote the creation of Trustworthy AI communities which would help solve "technical, societal, policy, legal and ethical challenges".
According to Davinder Kaur et. al. [**17**] to make an AI system trustworthy. In their view AI system would reach its full potential when the following principles/approaches are followed:

1) Principles of Respect for human autonomy
2) Principle of Prevention of harm
3) Principle of fairness
4) Principle of explicability

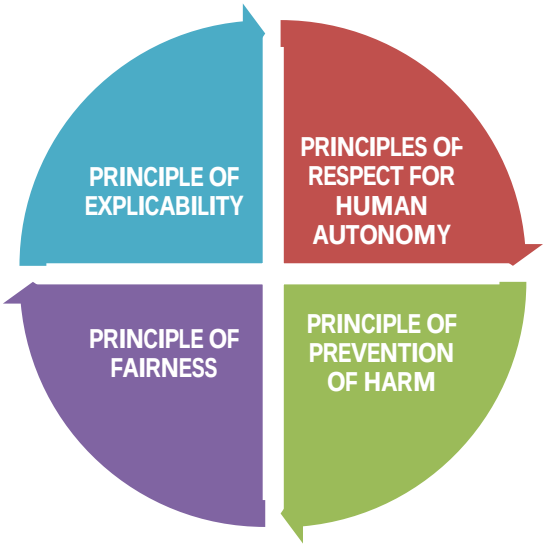


Figure 2:- Shows that for getting the full potential of AI the above mentioned Principles showed be followed.

According to Mona Simion et. al. [**18**], for an AI system to become fully trustworthy, the AI system must accomplish its functional obligations and always comply to the principles of trust, privacy, robustness and so on. AI system also make sure that trustworthiness is achieved in respect to policies, sciences and philosophies.

In their work [**19**], the author suggests a need for developing a "Global Framework" for TAI which would cover each and every aspect. As of now, there is not specific framework for TAI which would work for each and every application and each every scenario.

III. WATER DISTRIBUTION SYSTEM

Now coming to the Water Distribution Systems, India being a developing nation still relies heavily on manual work force and manual inputs to keeps it water distribution channels running. This creates several problems which relate to proper and timely resolution of consumer complaints. These complaints range from shortage of water supply to a certain sub-area or building due changes in elevation, resolution of leakage of damaged pipeline where water leakage occurs, water quality may not be up to mark due some reason, just to name a few.

In many instances, households complaint about the biasness of the employees in providing with adequate supply of water to the area of the employees or an area that they prefer. These problems pushed towards implementing this existing infrastructure with some modern technique.

This can be done by incorporating AI techniques and tools to the existing water channels which would help in monitoring each every aspect of the distribution system. As it can be seen in the work of Kyudae Shim et. al. [**20**], that Smart Water Solutions are used in supplying the city of Aracatuba in Brazil. The focus of this research was to implement smart water solutions to increase the efficiency of water supply which feeds the city.

Their suggestion is to monitor and analyze real time conditions of water supply system and provide ways for a proper and effective management of water. They use AI to make analytic decisions and perform analysis and interpretation on big data. Sensors are used to take a reading of water pressure and flow which helps detect water loss and areas of excessive water consumption. This helps in creating an optimal schedule based on the demands of the area.

In another instance Hubert Jenny, in their paper [**21**] throws light on the importance and potential of AI in enhancing the operational capabilities of water distribution systems. As the author suggests that digitalization of water distribution systems is essential to meet the challenges and issues in the everyday operations of water distribution systems. Doing this improvements can be made to existing water distribution channels, operational cost can be minimized and unaccounted water problems can also be tackled.

Further, to make sure that water distribution systems are optimal, fair and transparent we would need to incorporate the concepts, principles and guidelines of TAI.

IV. CONCLUSION

It can be simply concluded by saying that the future success of any major project whether governmental or non-governmental would be dictated by the ability of organisation to incorporate Artificial Intelligence in their day-to-day operational and functional needs. With AI, the computational and problem solving capabilities of computer devices has increased greatly. In continuation to this, AI systems can be used to increase the capabilities of existing infrastructure. This can be seen when AI systems are incorporated in water distribution systems to make them Smart Water Distribution Systems. As the use of AI applications has increased many concerns have been raised in the mind of the AI users across the globe regarding the probabilistic threats that AI may pose. To mitigate these problems and create respective counter measure, Trustworthy Artificial Intelligence is introduced. With TAI, lawfulness, ethics and robustness of any AI system can be insured which would further aid in mitigating the concerns of AI users regarding Privacy, Robustness, Fairness, Transparency and Explainability. Further research is being conducted by us to make Smart Water Distribution Systems effective and efficient.

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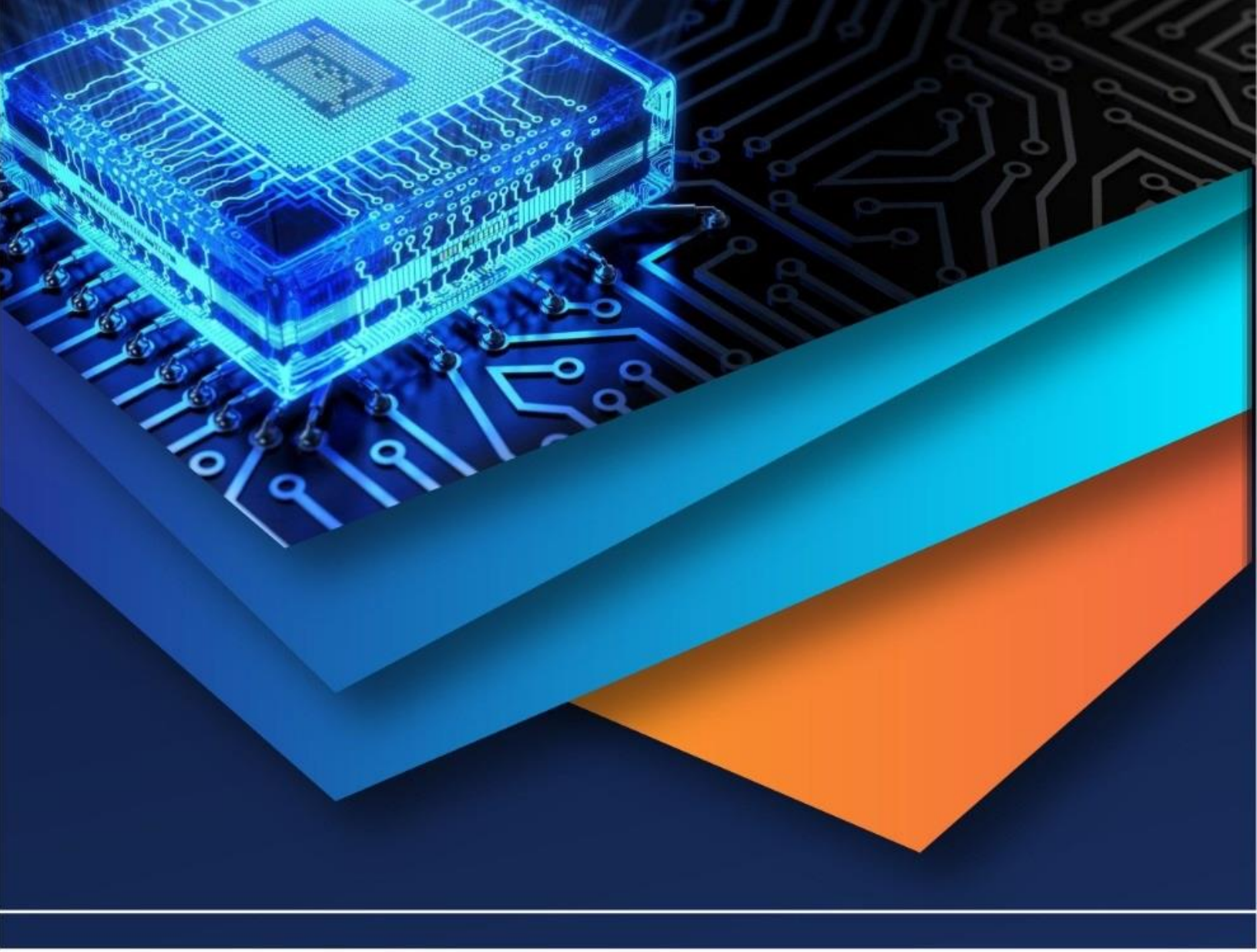
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