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## Role of Turing machine for smart environment: Open issues and critical challenges

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### Abstract

Today, in this world of cutting-edge technological development when human lives are becoming easier day by day, people begin to believe that no obstacle is difficult for a machine to solve. Yet there are large number of problems which machines are not able to solve from a very long time. So, in order to reach our goal for fully formulated smart environment, a small world where various types of smart devices can work tirelessly to make people work and life more easy, comfortable with sense of security which can be possible by IOT, AI and Machine Learning used together. So, there is an ever-desired need for machines to think and act like a human to achieve the goal for fully formulated smart environment. Therefore, in this paper, we are going to discuss what is a Turing Machine, the role of Turing Machine in Smart Environment, what are the issues in formulating the machine and critical challenges we are facing while implementing the idea. As we are already aware from the fact that Turing machine, as described by Alan Turing is “abstract computational machine”, but the common belief that the idea of a Turing machine is directly attached to Smart Environments like AI is criticized. So, the question arises whether Turing machine is relevant to Smart Environments like AI? If yes, then what are the challenges and how can we prove it?

**Keywords:** Turing machine, internet of things, machine learning, artificial intelligence, AI, ML, smart environment

### 1. Introduction

Every machine is different from one another with respect to their respective functions. Therefore, it is important to have a standard computational theory which can be used by all standard machines. There are various types of models of computer machines like NFA, DFA, PDA, DPDA where NFA stands for non-deterministic finite automata, DFA stands for deterministic finite automata, PDA stands for pushdown automata, and DPDA stands deterministic pushdown automata. But none of these are as effective as real machine or computer. Therefore, we need a model which can used in place of all other standard models<sup>[1]</sup>. This model is known as the Turing machine. Turing machines, first described by Alan Turing in Turing 1936-7, “are simple abstract computational devices” intended to help check the scope and restrictions of what can be computed<sup>[2,3]</sup>.

So, from the past century, Science and technology are going through many changes, Artificial intelligence has approached Computer technology to enhance its evolution. Artificial intelligence has created a dilemma among humans as Artificial intelligence has changed the idea of man towards machines as it acts like a human brain therefore it is also called manmade intelligence. So basically, Artificial Intelligence acts on a machine to perform intellectual operations. So, if these cognitive or intellectual operations can be described in the form of algorithms, then they can act like machine cognitive function.

So what people think of computation is some kind of stuff what the computers do, which is basically connected from the notion of Turing machine or a concept of logical system. Some people who criticize Artificial Intelligence assumed that Turing machine and its computational model is base study for the computers in Artificial intelligence and intellectual/cognitive science, which is matter of fact that people think that there are theorems which shows the limitation of Turing machine. This suggests that the wide viewed goal of Artificial Intelligence cannot be achieved<sup>[4]</sup>.

So basically, Artificial intelligence is used to construct a learning algorithm that can be run on machines such as human brain, that is, general purpose computational machines. So Artificial intelligence is a tool to build real intelligent machines. The neural networks make a small family of Artificial intelligence, therefore human brain is also called as BNN(Biological neural network)<sup>[5,6]</sup>.

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As we already know that brain is very complicated parallel computer. There is also learning technology in AI named Deep learning that deals with multi-layer leaning techniques.

**2. Neural Turing machine**

The aim of Neural Turing machine is to design a computational model which can fulfill the objectives of AI by designing learning algorithms that can be work such as the brain of the human. The new neural learning technology in Artificial intelligence is called as Deep Learning which tries to manage the cognitive problems and provides a system where human brain like pattern can be observed. NTMs are also greatest discovery which contributed a lot towards Machine learning. It opens the various options by which Machine learning can be used to learn various algorithms which can access an external memory. But as we already know that every discovery has its own limitations/problems. So as far we have seen how the neural Turing Machine can help in Artificial intelligence, Machine learning but there are many challenges also like:

- These are very hard to train in the first place-that is instability in numerical capability. Using memory in the architecture is also a cumbersome task, very difficult to use and it also requires smart optimization to its

problems.

- Heavenly dependent on architecture.
- There are very large number of parameters which puts huge amount of burden on Random Access Memory.
- Less effect on its performance even if the GPU is accelerated.

**3. Evolution**

<b>Artificial Intelligence</b>
Year 1950-Introduction of Turing Test by Alan Turing
<b>Machine Learning</b>
Year 1952-first program for computer learning
Year 1957-first neural network
<b>Deep Learning</b>
Year 2006-“Deep Learning” was introduced
Year 2012-First breakthrough by google in which it can identify cats.
Year 2014-Verification of people from photos by Facebook
Year 2016-Google's Alpha Go was the first who beats professional human Go player

Fig 1.0 shows the set wise architecture of smart environment with Artificial Intelligence, Machine learning and NTMs.

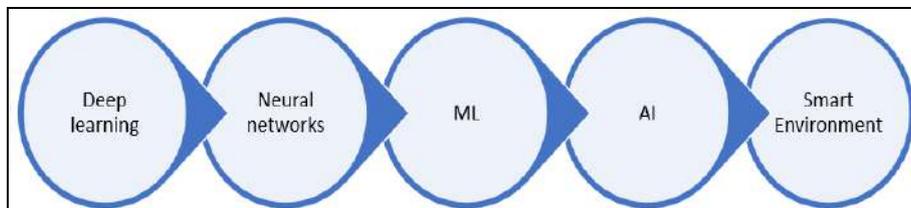


Fig 1: Shows the set wise architecture of smart environment with Artificial Intelligence, Machine learning and NTMs.

**4. Alan’s test for intelligence**

How do we know that the machine is thinking like a human brain? Are machines can really think like human way? If yes, then how do we know about it? What are the criteria when we can say the Turing machine is acting like a human? So, in order to resolve these kind of questions Alan Turing, in 1950 came up with a theoretical notion called Turing Test which has to be given by Turing Machine in order to test its intelligence. According to its proposed test, a machine with many other human candidates will be made to sit in a room and an examiner who will be notified that among all candidates there is one machine and you have to identify who is that [12]. The examiner will ask them questions in written form only, so in the end if the examiner fails to tell who is a machine, then this test for intelligence testing is consider to be pass otherwise fail. In Fig 2.0 assumed version of Turing test is shown which shows how the pictorial working of this test [8, 11].

In fig 2.0 there is an assumption that examiner and candidates are not talking face to face and communication is done only by means of chat format. Similarly, there is also a Test in which the roles are reversed like examiner is Machine and candidates are humans. Such test is called Reverse Turing test as shown in fig 3.0.

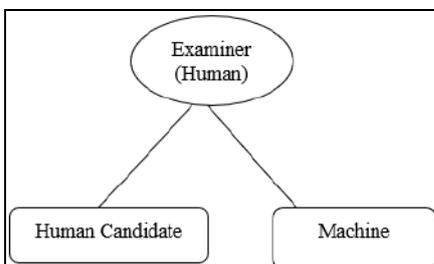


Fig 2: Shows working of Turing test.

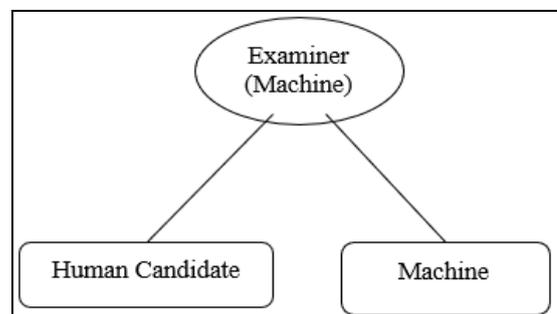


Fig 3: Shows working of Reserve Turing test.

In fig 3.0 there is an assumption that examiner and candidates are not talking face to face and communication is done only by means of chat format only.

**5. Difficulties and Challenges**

There are many challenges which we are facing in smart environment technologies. One of these challenges is to make machines think like a human and act like human so that they can make a good decision when in case human is

not available. It requires a large computation power for algorithms. Machine learning and deep learning are the two major pillars of AI and they have vast and complex computational requirements<sup>[9]</sup>. For a model to perform high performance and accuracy it requires smart optimization, large dataset and most important a well-furnished, correct algorithm with high computational power. It also requires a lot of training and testing and it is thousand times more than it looks.

Deep and Machine Learning models are based on the fact that a large amount of data is available to train them at first place. Let's suppose we have that data but then it creates the issues of data privacy and security. For example, suppose a organization is working in a city and it manages the data of a large number of people. But due to cyber-attack, all information regarding residents of the city who are serviced by that organization including personal information is leaked. This leakage of personal info into the hands of the people on the dark web creates a security concern for the people. So, we cannot totally neglect this possibility. But nowadays techniques have been introduced to tackle these concerns like we can train the models on smart devices and can make sure that the data is not sent back to the servers and ultimately after training part is complete, a complete trained model is sent back to the respective organization. But it still has its own pros and cons and also it doesn't completely eliminate the problem.

Other major problem that the AI is facing is to remove the biased nature of an AI system because it depends on category and amount of the data they were trained on. But if we talk about good AI than it should have a good data to feed on. Now as a matter of fact, majority of data that organization hold is poor and has no importance on its own. Therefore, we can say they are biased in nature as they define the interests to the limited number of people. So, in order to solve these problems, we have to make sure that some algorithms are defined that can productively check these kinds of problems. Fig 4.0 shows the various constituents, the AI should possess.

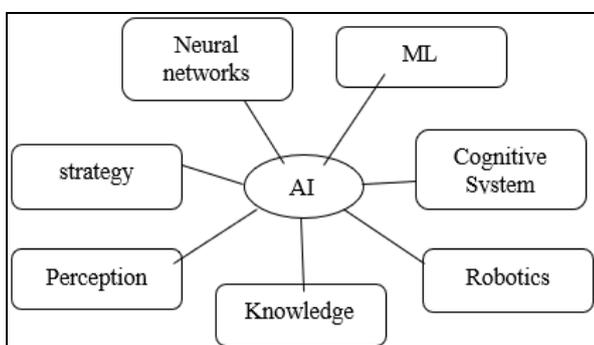


Fig 4: Shows the various constituents, the AI should possess.

## 6. Issues associated with the Turing test and artificial intelligence

As we have already discussed the working of the Turing test, so he asserted in his paper that by the starting of the 21st century, ideally programmed digital computers will be considered like a human brain prototype as the test will show that the machines think before answer the questions posed by humans. In order to accept the notion, the machines will need to pass the Turing test.

Turing's idea of defining whether the machines think or not

was really impressive but at the same time it also posed a lot of issues which questions its credibility.

1. Turing test didn't define the detailed test characteristics like number of observers, whether any qualification required or not, length of test to be taken. So basically, the Test didn't take into account a lot of more characteristics by which we can say the machine is actually thinking like a human<sup>[10]</sup>.
2. So, in order to solve this challenge, there were various ideas like by this test we only check if the machine can answer the questions of humans in familiar and rational way, then we can surely say they are thinking. But this assumption was not taken into account because a chat can tell us about the machine thoughts but it cannot tell us whether it is a thinking being or not because we humans take a lot of factors into consideration like appearance and consistency in response like being logical and forming a unified whole conversation in a consistent manner<sup>[13, 14, 15]</sup>.
3. So, we can say that, what Turing meant by thinking was mainly focused on prediction so people can use the word thinking in this context. So real question which arises is that, is this really THINKING what the AI assumed it to be? So, we can say in aspect of machine to be called thinking like a human, Turing Test with old definition cannot be the valid criteria to called a machine to be a thinking machine because it posses a lot of questions and contradictions. Suppose you are playing a chess game with a high-level computer. What do you think, will you be able to distinguish between a machine and human? The answer is clear NO. So basically, what we understand from the discussion is that aspect of thinking is not to give correct answers but sensitive answers also called responsive answers. So, by considering these arguments no machine has ever come in touch even with the boundary of real thinking.
4. The discussions of the above problems posed a great challenge for the Artificial Intelligence admirer. People and organizations have made very high-level programs and software's like Amazon Alexa, Apple Siri, Google Assistant which tries to do interaction with humans, provides various answers like another human being is talking to them, but even they are not able to pass the actual Turing Test. So now the real question arise whether Turing Test can be considered a valid Test for Artificial Intelligence? The answer of this question is unknown in the world of Artificial Intelligence because Turing at least shows some theoretical way of proving whether machines can be called as thinking or not. Apart from him, nobody till date has given any alternative idea about AI proving its claim of thinking like a human brain. So, we can say if there is no boundary then it will be impossible to say what is fit to be Artificial Intelligence and what is not fit. So basically, without the proper rule, every second App/software is nowadays called an AI even it nowhere resembles features of AI.

### The Chinese room problem and its contradiction

John Searle, a professor of philosophy in 1980 wrote a paper in which he criticizes the concept of Test as well as Strong Artificial Intelligence program. So basically, in Chinese room experiment setup, in which there is a room which is completely sealed except a small page like slot by which we can exchange paper from both sides. In the room, there is

only one person who don't know any Chinese but he has a dictionary. So people from outside send a paper in Chinese and he has to find the meaning of the characters from dictionary and pass them again to the outside people. So basically, what he is doing is just copying the meaning of the words/symbols from the dictionary after searching without understanding a single bit of meaning about the language.

So, from the point of view of the outside people, what they will think after receiving the paper is that in that room there must a translator or someone who understands Chinese but in reality, the person in the room don't understand anything about Chinese. An example of this experiment can be like we can consider test for students of a UG batch in this pandemic, so obviously it would be work from home only. A teacher has given a question for its class. Since the test is online so there is no invigilation and teacher cannot see them, only telling them to honestly give the test. In spite of that, the students copy paste from the web without even knowing the single concept about the topic in order to prove their intelligence in exam. So here the question arises whether the way of taking the test can be considered as effective measure of learning index/intelligence of students? Obviously, the test proved nothing about the class's intelligence. Even the student who has given the test by his hard work will get less marks from the Copying from internet which is perfect answer. So, in this example this test is a complete waste of time and resources as in the end the conclusion is NIL only.

So, from the demonstration of this experiment Searle insists that by replacing symbols without having any knowledge about the symbols, it is possible to have a effective and responsive communication with humans. So, what he proved from this experiment was that even if the computer/machine can communicate effectively with the humans but it doesn't mean that the machine is thinking. Hence, it was claimed that the passing of Test is no certification of agile intelligence.

But some artificial followers neglected the claims posed by Chinese room because they argue that may be all the sections of the Chinese room don't know Chinese but this system in whole does. They explained this by taking an analogy of the brain like thinking in brain is generated by whole brain, not by left hemisphere or right hemisphere of the brain. So, we can relate that thinking is the property of whole brain and done by in collaboration with all sections, hence cannot be attached with any one or two particular sections. So, it cannot be done on the basis of the few sections because the brain in whole was acting in thinking.

**Substitute/Changes in Turing test**

**1) Reverse Turing test (A variation of Turing test)**

Just opposite of Turing Test [7]. Examiner is machine rather than human, i.e., here human will try to satisfy the machine that he/she is not a machine.

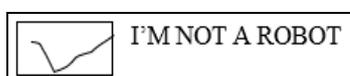


Fig 5: Shows how in everyday life we use reverse Turing test when machine checks for human intelligence.

**2) Total Turing test (A variation of Turing test)**

As we have discussed the issues with Turing test in where

detailed characteristics was not defined, so here in this case the examiner can also examine the perceptual ability and ability to handle the multiple objects-that is-It includes robotics to move them. So, in order to pass this, test the computer will need as shown in Fig 6.0.

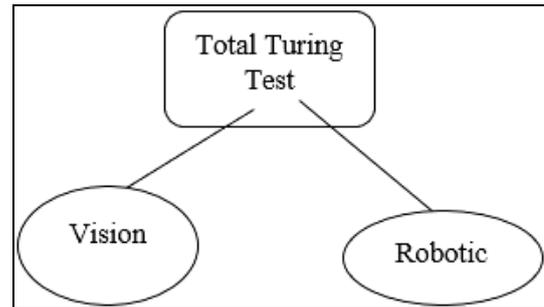


Fig 6: Shows Total Turing Test components.

**3) Minimum intelligence signal test (A variation of Turing test)**

This test is also called MIST and was first proposed by Chris McKinstry. This test asks questions such that the answers can be given in one word, i.e., Yes/No as in Fig7.0 or True/False. So, we can say only Boolean answers are allowed in this variation.

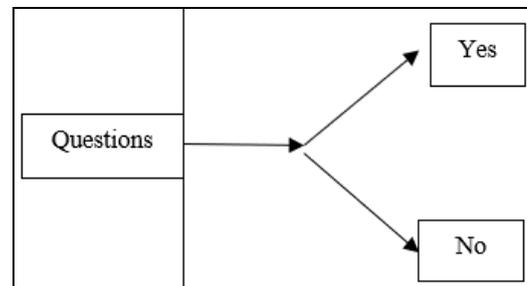


Fig 7: Shows the working of Intelligence Signal test.

**4) The Marcus test (Alternative to Turing test)**

When people found out that there are some contradictions also in Turing test then these alternative tests came into picture. Marcus test is basically a Watch and Ask test where a machine will be made to see a TV show and on the basis of the show's details relevant questions will be asked.

**5) The Lovelace test 2.0 (alternative to Turing test)**

In this test, primary motive for testing the Artificial Intelligence was by using Arts, i.e., whether an AI can create art or not.

**6) Winograd schema challenge (alternative to Turing test)**

In this test, questions are asked in the form of MCQs (Multiple Choice Questions).

**Original Turing test in 21<sup>st</sup> century**

1) In 2014, University of Reading organized a competition to remember Turing during his 60th death anniversary, a algorithmic program was made by the team of Russian team which used to communicate by chat. This program act as a 13-year-old Ukrainian boy called Eugene Goostman and most astonishing fact about this conversation was that this program managed to fool 33% of the total judges. So some people say that this program

passed the Turing test. Obviously fooling one third of the judges was not a very big feat and hence it doesn't justify claims that the Turing Test was passed. This test was also linked-up with criticism that there were few judges and the time duration of the test was very less.

According to Scott Aaronson, from Massachusetts Institute of Technology had said that the conversation which Eugene

did was very high than any other chatbot. So, in order to remove further unusual publicity, he decided to probe further and asked Eugene some more questions to clear the doubt whether this machine has passed the Turing test which many was claiming. So here are some more questions which he asked which shows his limitations and how everything was just a hoax. The later conversation between Scott and Eugene is given below.

<b>Scott:</b> "Do you understand why I'm asking such basic questions? Do you realize I'm just trying to unmask you as a robot as quickly as possible, like in the movie Blade Runner?"
<b>Eugene:</b> "wait"
<b>Scott:</b> "Do you think your ability to fool unsophisticated judges indicates a flaw with the Turing Test itself, or merely with the way people have interpreted the test?"
<b>Eugene:</b> "The server is temporarily unable to service your request due to maintenance downtime or capacity problems. Please try again later."
<b>Scott:</b> "I guess we won't be needing Blade Runners just yet."

2) Google duplex in 2018, made an appointment with the hairdresser and in the process the receptionist was totally uninformed that she was not talking to real human. This deed was accomplished while 7k people were watching live. This is not exactly a Turing test pass but for some people "modern-day" Turing test pass.

Hence in the last, readers are recommended to go through articles [16-20] to know about emerging techniques, raised problems/ issues like security, privacy, etc., in the previous decade in various computing platforms in detail.

**7. Conclusion**

After going through so many variations and alternatives to find the ideal test/rule to define the Artificial Intelligence existence, the original version of the rule is still used today. Likewise, from 1991, Hugh Loebner, a New Jersey based businessman started the Loebner Prize Competition in AI in which the aim was to choose the winner team of the year on the basis of AI which can perform as nearest as Turing explained it. From that year this competition is held every year to choose a machine who act like a human by following the Turing Test standard rules.

So, after much discussion about Turing Test, pros and cons, its variations and alternatives, the Turing test still exists today as old wise man which gives valuable starting lessons and provide a platform for debate and reviewing AI. As we are going deep in Artificial Intelligence day by day but our foundation of AI remained same for explaining intelligence and is a starting point for debating, what should be our technology/test which makes ideally and virtually possible to call the machines as Thinking Brains.

After all, I can say one thing about validation of strong AI that only criticizing Turing Test is wrong and should be stopped immediately because people don't have any other idea which can prove and answer the real question "Whether machine thinks like a human brain"? And they just want others to leave the only available idea which may also not be able to tell the answer but still it is a very good test for intelligence and possibly the only option which is available. So, basically, we are improving the machines day by day and I believe that by gaining the knowledge from these machines, we will be able to find the solution to correct Turing Test. It's always better to believe in hope rather than living in uncertainty.

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