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Turing's 1948 'Paper Chess Machine' Test as a Prototype of the Turing Test

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Introduction

The Turing test (hereafter TT) is one of the mostly discussed and inspiring ideas concerning intelligent machines. Its influence reaches many disciplines, ranging from artificial intelligence and cognitive science, to philosophy and psychology – see the overviews presented in *The Turing Test. Verbal Behaviour as the Hallmark of Intelligence*[1] and *Parsing the Turing Test. Philosophical and Methodological Issues in the Quest for the Thinking Computer*.[2] Theoretical discussions aside (considering issues like, e.g. the TT as a definition of intelligence or judges' bias in the TT setting), nowadays we have also practical realisations of the test in the form of the Loebner contest[3] and tests organised by Reading University.[4] There are

[1] Stuart Shieber (ed.), *The Turing test: Verbal behavior as the hallmark of intelligence* (Cambridge, Massachusetts: MIT Press, 2004).

[2] Epstein Robert, Gary Roberts, Grace Beber (eds.), *Parsing the Turing test*. *Philosophical and Methodological Issues in the Quest for the Thinking Computer* (Berlin–Heidelberg: Springer, 2009).

[3] Hugh Loebner, "How to Hold a Turing Test Contest", in: R. Epstein, R.G. Roberts, G. Beber (eds.), *Parsing the Turing Test...*, chap. 12, 173–180.

[4] Kevin Warwick, Huma Shah, "Human misidentification in Turing tests", *Journal of Experimental & Theoretical Artificial Intelligence* 27(2) (2015): 123–135; Kevin Warwick, Huma Shah, "Effects of lying in practical Turing tests", *AI & SOCIETY* 31(1) (2016): 5–15.

also many proposals for improving[5] or replacing the original test.[6] This makes it possible to put Turing's theoretical assumptions and ideas to work and examine them.

In this context, a question arises – is it the case that Turing himself considered the idea of testing the abilities of computing machines as merely a task for future? What I would like to show in this paper is that the TT proposed in Turing's seminal 1950 paper was a consequence of his previous ideas, considerations, and practical trials. The test for thinking machines is rooted in the idea of imitation explored by Turing for the domain of mathematics and his experimentation with playing games. What is more, we may identify not only a prototype for the TT (i.e. the 'paper chess machine'), but also find traces of active experimentation with this prototype.

My main source in this paper is an unpublished report entitled *Intelligent Machinery* (dated 1948, 37 numbered pages). The original typescript is available in *The Turing Digital Archive* as the document ATM/C/11.[7] This report is often referred to as "the first manifesto of AI"[8] as it covers topics such as the logic-based approach to problem solving, anticipation of genetic algorithms, and neural networks. It is Copeland, who pointed out that the *Intelligent Machinery* contains "the earliest description of (a restricted form of) what Turing was later to call the 'imitation game' and is now known simply as the Turing test",[9] however he does not explore this idea in detail. In this paper I would like to analyse similarities between a test for the paper chess machine and TT rules and design.

The structure of the paper is as follows: Section *The test for thinking machines* presents the reconstruction of the design and rules of the TT. The next section refers to the idea of the paper chess machine and makes a comparison with the setting of the TT. There I also discuss how the paper chess machine was tested by Turing.

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[5] See e.g. Roby Garner, "The Turing Hub as a Standard for Turing Test Interfaces", in: R. Epstein, R.G. Roberts, G. Beber (eds.), *Parsing the Turing Test...*, chap. 19, 319–324.

[6] See e.g. Michael L. Mauldin, "Chatterbots, Tinymuds, and the Turing test: Entering the Loebner prize competition", in *Proceedings of the Twelfth National Conference on Artificial Intelligence* (Vol. 1), American Association for Artificial Intelligence, Menlo Park, CA, USA, AAAI 1994, 16–21, and Chris McKinstry, "Minimum Intelligence Signal Test: an Objective Turing Test", *Canadian Artificial Intelligence* 41 (1997): 17–18.

[7] Alan M. Turing, *Intelligent Machinery*, The Turing digital archive (http://www.turingarchive.org), contents of AMT/C/11, 1948. *Intelligent Machinery* is also available in the collection of Turing's works: Brian Jack Copeland (ed.), *The Essential Turing: Seminal Writings in Computing, Logic, Philosophy, Artificial Intelligence, and Artificial Life: Plus The Secrets of Enigma* (New York: Oxford University Press, 2004).

[8] Copeland, *The Essential Turing*, 2.

[9] Ibidem, 401.

The Test for Thinking Machines

The Turing test description presented in *Computing Machinery and Intelligence*[10] leaves some space for interpretation. As a result the TT is conceptualized in many non-equivalent ways, some of them showing only a distant resemblance to Turing's original idea.[11] Here I would like to present the TT setting and rules reconstruction[12] based on several Turing sources including: *Computing Machinery and Intelligence*, *Can Digital Computers Think*, *Intelligent Machinery, a Heretical Theory*, *Can Automatic Calculating Machines be Said to Think?*, and *Digital Computers Applied to Games*. These sources give the following image of the basics of the TT.

Setting. The TT resembles the so-called imitation game, but the analogy is not complete. The imitation game involves three players: a man (A), a woman (B), and an interrogator; the objective of an interrogator is to identify which of the players, A and B, is a man, and which is a woman. The objective of an interrogator in the TT is different: he/she aims at an identification of a machine that 'thinks'. Therefore only two parties are needed: an interrogator (sometimes referred to as a judge) and a tested agent. In *Computing Machinery and Intelligence*, Turing uses the term *viva voce* for the version of a game.[13] In his later works Turing straightforwardly refers to the TT as to a two-parties enterprise. For example, in *Digital Computers applied to games* one reads: "I am imagining something like a viva-voce examination, but with the questions and answers all typewritten in order that we need not consider irrelevant matters such as the faithfulness with which the human voice can be imitated".[14] This setting is presented in Figure 1.

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[10] Alan M. Turing, "Computing machinery and intelligence", *Mind*, LIX(236) (1950): 443–455.

[11] See discussion in: Paweł Łupkowski, *Test Turinga. Perspektywa sędziego* (The Turing Test. Interrogator's Perspective) (Poznań: Wydawnictwo Naukowe UAM, 2010); idem, "A Formal Approach to Exploring the Interrogator's Perspective in the Turing Test", *Logic and Logical Philosophy*, 20(1/2) (2011): 139–158; idem, Andrzej Wiśniewski, "Turing interrogative games", *Minds and Machines*, 21(3) (2011): 435–448.

[12] This reconstruction was prepared for, and presented in previous publications including Łupkowski, *Test Turinga…* and idem, Wiśniewski, *Turing interrogative games*.

[13] Turing, *Computing Machinery and Intelligence*, 446.

[14] Alan M. Turing, *Digital computers applied to games*. The Turing digital archive (http://www.turingarchive.org), contents of AMT/B/7 (1953), 4–5.

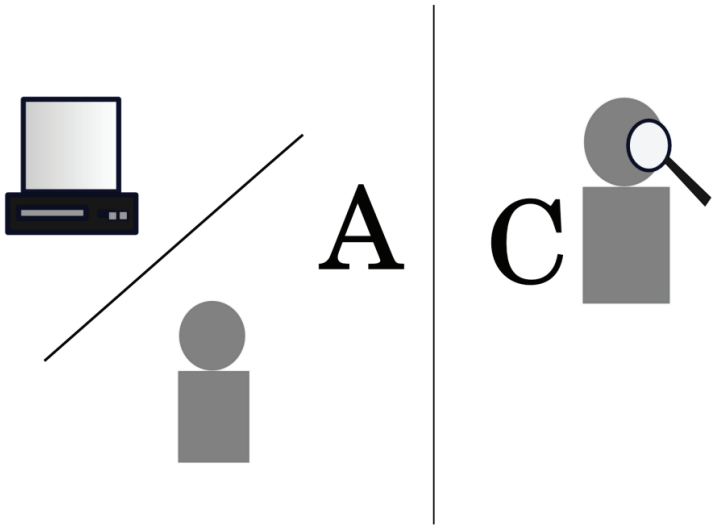

Figure 1. The Turing test setting (in the viva voce form).

Interrogator. The interrogator is not supposed to know the identity of the tested agent. The parties cannot see or hear each other. As Turing puts it: "A considerable proportion of the jury, who should not be expert about machines, must be taken in by the pretence. They aren't allowed to see the machine itself – that would make it too easy. So the machine is kept in a room a long way away and the jury are allowed to ask it questions, which are transmitted through to it: it sends back a typewritten answer".[15]

Aim. The game is played by means of questions and answers. In *Can Automatic Calculating Machines be said to think?* one reads: "The idea of the test is that the machine has to try and pretend to be a man, by answering questions put to it, and it will only pass if the pretence is reasonably convincing".[16] The aim of a tested AI agent is to mislead the interrogator in such a way that he/she would not be able to make an accurate identification. The agent should attempt to answer questions in a human-like manner, and can even use some tricks to achieve this, e.g. can make mistakes in calculations, or spelling mistakes, etc. "Likewise the machine

[15] Newman Maxwell Herman, Alexander Newman, Alan Turing, Geoffrey Jefferson, Richard Braithwaite, *Can automatic calculating machines be said to think?*, Broadcast discussion transmitted on BBC (14, 23 Jan 1952). The Turing digital archive (http://www.turingarchive.org), contents of AMT/B/6, 4.

[16] Ibidem, 4.

would be permitted all sorts of tricks so as to appear more man-like, such as waiting a bit before giving the answer, or making spelling mistakes".[17]

The main objective of the TT is to differentiate between AI agents that 'think' and AI agents that do not. If an AI agent passes the test, then, owing to a certain abductive reasoning, one has good reasons to believe that the agent 'thinks'.[18]

Restriction of topics. An interrogator is free in his/her choice of questions asked; Turing does not impose any restrictions here. He writes in *Computing Machinery and Intelligence*: "The question and answer method seems to be suitable for introducing almost any one of the fields of human endeavour that we wish to include".[19]

Duration. An agent should be tested long enough to gain more reliable results. As is clearly stated in *Can Digital Computers Think?*: "We had better suppose that each jury has to judge quite a number of times, and that sometimes they really are dealing with a man and not a machine. That will prevent them saying 'It must be a machine' every time without proper consideration".[20]

Paper Chess Machine

Turing starts the *Intelligent Machinery* report with setting its main goal to "(...) investigate the question as to whether it is possible for machinery to show intelligent behaviour".[21] As he claims, one should not be hasty in reaching the conclusion that it is not possible, especially without considering any arguments in favour of such a concept.

Turing is aware that the computing machines of his day were not advanced enough and that their abilities were not impressive. He analyses different types of possible solutions and their technical details introducing "discrete" and "continuous" machinery and further "controlling"

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[17] Ibidem, 5.

[18] Cf. discussions in James Moor, "An Analysis of the Turing Test", *Philosophical Studies* 30 (1976): 249–257, and Douglas F. Stalker, "Why machines can't think: A reply to James Moor", *Philosophical Studies* 34 (1976): 317–320.

[19] Turing, *Computing Machinery and intelligence*, 435. This is then confirmed in *Can automatic calculating machines be said to think?* where one reads: BRAITHWAITE: "Would the questions have to be sums, or could I ask it what it had had for breakfast? TURING: Oh yes, anything. And the questions don't really have to be questions, any more than questions in a law court are really questions. You know the sort of thing. "I put it to you that you are only pretending to be a man" would be quite in order". Newman, Turing, Jefferson, Braithwaite, *Can automatic calculating machines be said to think?*, 5.

[20] Turing, *Can Digital Computers Think?*, 5.

[21] Turing, *Intelligent Machinery*, 1.

and "active" machines.[22] However, from the perspective of this paper one additional type of "machine" is especially interesting – namely the paper machine. Turing describes it in the following manner:

> It is possible to produce the effect of a computing machine by writing down a set of rules of procedure and asking a man to carry them out. Such a combination of a man with written instructions will be called a 'Paper Machine'. A man provided with paper, pencil, and rubber, and subject to strict discipline, is in effect a universal machine.[23]

In my opinion, by the simple step of introducing the idea of a paper machine Turing provided a platform for an intuitive and convincing way of discussing thinking machines. This opened a door for presenting advanced computations in a simple and illustrative way, without the necessity of referring to the formal model of computation represented by Turing machines. 'Paper machine' clearly relates to the imitation idea which serves as the cornerstone for Turing's considerations of intelligence.[24] Paper machine is an imitation of a universal computing machine. As discussed, this concept is extended to the thinking of machines. Turing writes:

> One way of setting about our task of building a 'thinking machine' would be to take a man as a whole and to try to replace all the parts of him by machinery. He would include television cameras, microphones, loudspeakers, wheels, and 'handling servo-mechanisms' as well as some sort of 'electronic brain'. This would be a tremendous undertaking of course. (...) Thus although this method is probably the 'sure' way of producing a thinking machine it seems to be altogether too slow and impracticable.[25]

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[22] See ibidem, section "Varieties of machinery".

[23] Turing, *Intelligent Machinery*, 11.

[24] The idea of imitation is used by Turing for the abstract computation models, i.e. Universal Turing Machines: "In order to arrange for our computer to imitate a given machine it is only necessary to programme the computer to calculate what the machine in question would do under given circumstances, and in particular what answers it would print out. The computer can then made to print the same answers". Turing, *Can digital computers think?*, 2. Such an approach is then extended to the analysis of human intelligence. As Turing writes: "My contention is that machines can be constructed which will simulate the behaviour of the human mind very closely. They will make mistakes at times, and at times they may make new and very interesting statements, and on the whole the output of them will be worth attention to the same sort of extent as the output of a human mind". Alan M. Turing, *Intelligent machinery, a heretical theory*. The Turing digital archive (http://www.turingarchive.org), contents of AMT/B/4, 1951, 2 (see also Newman, Turing, Jefferson, Braithwaite, *Can automatic calculating machines be said to think?*, 3–4).

[25] Turing, *Intelligent Machinery*, 11–12.

Instead we should focus on "a 'brain' which is more or less without a body, providing, at most, organs of sight, speech, and hearing".[26] This leads us to the second step taken in the analysed typescript, which is to choose a well-known field of human expertise that is related to intelligent behaviour and will make it possible "(...) for the machine to exercise its powers in".[27] Turing points at games (e.g. chess, noughts and crosses, bridge, poker); the learning of languages, translation, cryptography, and mathematics. He stresses that games and cryptography especially are worthy of interest as "they require little contact with the outside world".[28] In what follows he focuses on chess and claims that "[o]ne can produce 'paper machines' for playing chess. Playing against such a machine gives a definite feeling that one is pitting one's wits against something alive".[29]

As Turing stresses, "[a] great positive reason for believing in the possibility of making thinking machines is the fact that it is possible to make machinery to imitate any small part of a man".[30]

And now we reach the concluding paragraph of the analysed report. Here Turing proposes the following interesting experiment which involves all the concepts and ideas introduced above.

> It is possible to do a little experiment on these lines, even at the present stage of knowledge. It is not difficult to devise a paper machine which will play a not very bad game of chess. Now get three men as subjects for the experiment A, B, C. A and C are to be rather poor chess players, B is the operator who works the paper machine. (In order that he should be able to work it fairly fast it is advisable that he be both mathematician and chess player.) Two rooms are used with some arrangement for communicating moves, and a game is played between C and either A or the paper machine. C may find it quite difficult to tell which he is playing. (This is a rather idealized version of an experiment I have actually done.)[31]

At first, let us take a closer look at the intended schema of the proposed experiment. It is illustrated in Figure 2. This schema is exactly the same as in the case of the TT. We have three participants, one of whom plays the role of a judge for the test (C) and two others are tested chess players. Participants should not see each other (they are placed in two separate rooms), they only communicate moves using "some arrange-

[26] Ibidem 12.
[27] Ibidem.
[28] Ibidem.
[29] Ibidem, 4.
[30] Ibidem, 16.
[31] Ibidem, 37.

ment". The goal of the experiment is that C should be able to tell which one he is playing against: a human or a paper machine. What is interesting, is that this paper chess machine test favours a scenario where a judge plays only with one of the players and he does not know which one ("a game is played between C and either A or the paper machine"). This allows the avoiding of many methodological issues raised against the TT version, where the judge tests two players simultaneously (discussed especially in the context of the Loebner contest).[32]

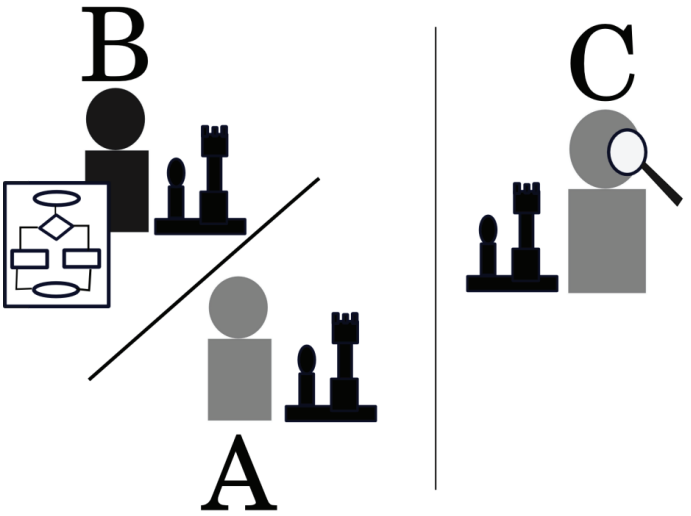

Figure 2. The paper chess machine test as described in the *Intelligent Machinery* report.

There are further analogies to the Turing test. As for the judge, Turing writes that he should be rather poor chess player. This restriction is aimed to exclude a chess expert for whom the task of recognising the paper machine would be rather simple. This issue is discussed in *Computing machinery and intelligence* and *Can automatic calculating machines be said to think?* where Turing excludes experts in computing machinery as judges in the TT.[33]

One may easily notice that the test for paper chess machine has the same setting, aim, and judge requirements as will be later formulated for

[32] See an overview in Paweł Łupkowski, "Measuring the non-cooperation of players – a Loebner contest case study", *Homo Ludens* 5(1) (2013): 13–22, and Paweł Łupkowski, Aleksandra Rybacka, "Non-cooperative Strategies of Players in the Loebner Contest", *Organon F* 23(3) (2016): 324–365.

[33] Turing, *Computing machinery and intelligence*, 442, and Newman, Turing, Jefferson, Braithwaite, *Can automatic calculating machines be said to think?*, 4.

the TT. As we are considering only a chess game, the restriction of the topic to the discussed paper machine test seems natural. Also, the issue of the length of the test is not discussed here. This seems natural, as chess rules regulate the stop condition for testing quite clearly as we know exactly when a game ends.

It is also worthwhile to pay attention to the last line of this quotation (and the line that concludes the report). It seems that Turing himself experimented with this idea. This would suggest that the TT setting was tested before its formulation, and perhaps this paper chess machine test influenced the final form of the TT. This is of course only a speculation as Turing does not state this in his notes or papers. However, from his biography we know that Turing was very interested in chess.[34] At Bletchley Park he even took some lessons from more advanced colleagues. He invented "Round-the-house" chess, when moves are separated by a run around the house.[35]

As Copeland points out, Turing's ideas about the mechanization of chess date back as far as 1941.[36] In 1948 Turing (together with an economist David Champernowne) designed a chess playing algorithm named "Turochamp".[37] He actually tested the algorithm using pen and paper calculations. Friedel and Kasparov[38] point that about half an hour calculation was required for each move. The game Turing played against his colleague Alan Glennie has even been recorded – for the transcript see Kasparow and Friedel *Reconstructing Turing's 'paper machine'*. The aforementioned publication describes also G. Kasparov's game against the "Turochamp". Kasparov's evaluation is as follows: "(...) the game was played and there were 29 moves, not just legitimate moves, but you may call them decent moves".[39] Turing even started implementing the algorithm on the Ferranti Mark I computer (at Manchester University) in the early 1950s, but he never completed this work.[40]

These facts show that Turing not only thought about testing machines in the field of thinking, but also exercised this idea in practice. The paper chess machine, its testing, and the implementation attempts suggest that this idea might have been a prototype and a test field for the TT.

This reveals the practical aspects of Turing's approach. There are many theoretical papers addressing TT issues, which are not fully ex-

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[34] See Andrew Hodges, *Alan Turing: the Enigma*, New York: Vintage Books, 1992.

[35] See Garry Kasparov, Frederic Friedel, "Reconstructing Turing's 'paper machine'", *ICGA Journal*, 40(2) (2018): 105–112.

[36] Copeland, *The Essential Turing*, 563.

[37] Ibidem.

[38] See: Kasparov, Friedel, *Reconstructing Turing's 'paper machine'*.

[39] Ibidem.

[40] Copeland, *The Essential Turing*, 564; Kasparov, Friedel, *Reconstructing Turing's 'paper machine'*.

plained in *Computing Machinery and Intelligence*. It seems that Turing's answer to the discussions concerning these issues would be simply: just *try* different settings. In *Computing Machinery and Intelligence* he writes:

> We may hope that machines will eventually compete with men in all purely intellectual fields. But which are the best ones to start with? Even this is a difficult decision. Many people think that a very abstract activity, like the playing of chess, would be best. It can also be maintained that it is best to provide the machine with the best sense organs that money can buy, and then teach it to understand and speak English. This process could follow the normal teaching of a child. Things would be pointed out and named, etc. Again I do not know what the right answer is, but I think *both approaches should be tried*.[41]

Summary

My aim in this paper was to present the paper chess machine and the idea of testing it against a human chess player. In my opinion these served as a prototype for the well-known Turing test. One may notice that the paper chess machine test and the TT share the same design, aims, and requirements for a judge. What is more – on the basis of the 1948 idea – I argue that Turing advices active experimentation with and fine tuning of the TT proposal.

I would like to end this paper by pointing out the fact that Turing was also aware of certain limitations of the imitation approach he adapted. As I discussed in the section concerning the TT rules and setting, Turing was far from seeing the TT as a simple operationalisation of the intelligence definition. He clearly adopts an analogical approach to the paper chess machine test. In the technical essay *Digital Computer Applied to Games* (1953) considering the chess playing algorithm, he revisits the 1948 idea. Turing starts with a remark that a question "Could one make a machine to play chess?" may have several meanings. Two of them are more general and interesting from our perspective, namely:

a) Could one make a machine which would answer questions put to it, in such a way that it would not be possible to distinguish its answers from those of a man?
b) Could one make a machine which would have feelings as you and I do?

To a) Turing replies "I believe so. I know of no really convincing argument to support this belief and certainly of none to disprove it.", while his answer for b) is "I shall never know, any more than I shall ever be quite certain that *you* feel as I do".

[41] Turing, *Computing machinery and intelligence*, 460.

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Summary

The aim of this paper is to present the idea which served as a prototype and probably a test field for the idea of the well-known Turing test. This idea is the 'paper machine' (an algorithm) for playing chess and the proposal to test its abilities in confrontation with a human chess player. I will describe the details of this proposal and discuss it in the light of the Turing test setting.

Keywords: Turing test, intelligence, chess, imitation game, paper machine

Streszczenie

Turinga propozycja testu dla „papierowej maszyny szachowej" z 1948 roku jako prototyp dla testu Turinga

Celem niniejszego artykułu jest omówienie idei, która posłużyła jako prototyp oraz prawdopodobnie pole testowe dla propozycji znanej jako test Turinga. Ideą tą jest „papierowa maszyna" (algorytm) zaprojektowana w celu gry w szachy oraz pomysł przetestowania jej możliwości w konfrontacji z ludzkim szachistą. Opiszę tę ideę oraz przedstawię jej znaczenie w kontekście testu Turinga.

Słowa kluczowe: test Turinga, inteligencja, szachy, gra w udawanie, papierowa maszyna