The search for life in the Universe
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Annotation. In the paper we propose another way in contacting other civilizations. We give an explanation why Fermi paradox exists ie we explain the Great Silence.
Keywords: Automata; up-and-down; Van Der Pol equation; complexity

1. Introduction

In the book [1] in the article by A. D. Ursul there is given a formula that shows when the contact between Earth and other civilization is possible

\[ \frac{R_1}{C_1} = \frac{R_2}{C_2}, \tag{A} \]

where \( R \) means the result obtained from such contact and \( C \) means the costs to establish the contact. The corresponding superscripts denote Earth and other civilization corresponding results and costs.

There is well-known Fermi paradox that is the apparent contradiction between high estimates of the probability of the existence of extraterrestrial civilizations and the lack of evidence for such civilizations.

So, the formula (A) is not fulfilled. If we denote by \( \eta \) the corresponding fraction of the result and cost for Earth and by \( \pi \) for other civilization, then we see that

\[ \eta < \pi. \]

If it was otherwise, then obviously the contact would already happened.

Hence we see that \( \eta \) is smaller than needed.

So, one way to contact another civilization is to make \( \eta \) bigger.

As one can see the natural way is to try to reduce the costs by this making \( \eta \) to grow.

In the article mentioned above it is not said exactly what costs mean. In the below discussion we try to formalize the meaning of costs by utilizing the notion of Automaton since such a notion should be common in both civilizations.
Let us study the possibility for a Finite State Automaton (FSA) to find a signal masked by the noise ("white noise").

2. Main result

Let us recall definition of FSA. More precisely, a definition of a transducer.

Definition
A finite state transducer is a sextuple \((\Sigma, \Gamma, S, s_0, \delta, \omega)\), where:

- \(\Sigma\) is the input alphabet (a finite non-empty set of symbols).
- \(\Gamma\) is the output alphabet (a finite, non-empty set of symbols).
- \(S\) is a finite, non-empty set of states.
- \(s_0\) is the initial state, an element of \(S\).
- \(\delta\) is the state-transition function: \(\delta : S \times \Sigma \rightarrow S\).
- \(\omega\) is the output function \(\omega : S \times \Sigma \rightarrow \Gamma\).

Let us consider the case when \(\Sigma = \Gamma = \{0, 1\}\). Other cases can be considered similarly.

Definition
A signal is a sequence \(\alpha = (a_1, ..., a_n) \in \{0, 1\}^n\) of 0 or 1 of length \(n\).

Definition
A signal \(\beta = (\beta_1, ..., \beta_n)\) is called masked by the noise if there exists a random vector \(\xi = (\xi_1, ..., \xi_n)\) with values in \(\{0, 1\}^n\) such that

\[
\beta = \alpha \oplus \xi, \quad E(\xi_i) = 1/2 \text{ for } i = 1, ..., n \text{ and for all } n
\]

where \(\oplus\) is a boolean addition and \(E\) is an expected value of \(\xi\).

For simplicity, we let \(\xi_i = \xi\) for all \(i\) where \(\xi\) is some random variable.

Let there be a transducer \(A = (\Sigma, \Gamma, S, s_0, \delta, \omega)\) and let \(\beta\) be its input signal. The transducer output signal is denoted by \(\gamma\).

Definition
We call a transducer \(A = (\Sigma, \Gamma, S, s_0, \delta, \omega)\) capable of recognizing a signal \(\alpha\) if

\[
D(\gamma_n - \beta_n) \rightarrow 0
\]

when \(n \rightarrow \infty\), where \(D\) is a variance and minus means binary subtraction.
Definition
Up-and-down automaton is an automaton for which the output signal is determined by the rules
- if input is 1 and previous input is 0, then the output is 1,
- if input is 0 and previous input is 1, then the output is 0,
- if input is 0 and previous input is 0, then the output is 1,
- if input is 1 and previous input is 1, then the output is 0,
- if no previous input, then the output is BLANK.

As one can see Up-and-down automaton is an automaton that follows the input by taking the previous input and inverting it, and it reminds a well-known method from statistics theory called up-and-down method since it is based on the same principle - “up-and-down” [3].

Example of such up-and-down automaton is given on Pic. 1.

Pic. 1 Example Up-and-down automaton with initial state $s_1$ - “white rabbit”.

Theorem.
Up-and-down automaton is capable to recognize any signal $\alpha$.

Proof.
Self-evident. It follows from (2).
QED

Theorem P.
Any transducer that is not equivalent to Up-and-down automaton is not capable to recognize all signals (there exists a signal $\alpha$ that (2) is not fulfilled).

Proof.
If such transducer exists that is not equivalent to Up-and-down automaton and that is capable to recognize all signals, then it will be complex enough. It must be able to recognize waves as possible signals. The work of such transducers can be described through work of electronic elements and their schemas. It is seen that this transducer will contain enough complex elements such as depicted on the Pic. 2.
The signal inside schema depicted on Pic. 2 is described by Van Der Pol equation

\[ x'' + \lambda(x^2 - 1)x' + x = 0 \]  

(3).

See [2] for further discussions. It is known that (3) possess solutions with phase portrait depicted on Pic. 3.

If \( \lambda = 0 \), then the solution is harmonic oscillation.

Basicly the output of such transducers is superposition of harmonic oscillations. As one can see such transducers can not predict any input signal except of the same type - waves - they are too predictable themselves.

QED

3. Conclusion

The above results can be generalized for the case of “white noise” and bigger input-output alphabets \( \Sigma, \Gamma \) since any of those can be “digitized”.

The results can be generalized to other automata because the result is general and relies only on the theory of differential equations [2].

Such methods give another way in understanding the “reality”.
Theorem P explains why there is the Great Silence: simply people “do not hear” the signals from other civilizations (kind of blind) because their costs or in other words their complexity in everyday life is too high. By this not fulfilling the formula (A).

Let us show that people knowledge is already “injected” with some “other” civilization knowledge in order to show they exist and show the “path” to them.

Such “injection” proposition is Godel Theorem. Let us show why.

Let show that everything what people create leads to an exception ie to trauma. It is so because everything what they do is based on arithmetic. Hence Godel Theorem is applied. Hence there is always exception in people’s environment. This results in trauma eventually, even a hammer can bring trauma since its work is based on arithmetic too - number of hammer movements.

From the above results it follows that people need not create anything. As a logical consequence it follows that everything is created before them - they are given knowledge “how the stuff works” so that they understand from where the knowledge comes. Further it shows that people are just automata of those who created them - Old Civilization. Since Automaton is a common notion in any civilization.

**Discussion of obtained result**
The only thing what is needed is to live simple life and do not create anything because this will lead to exception due to Godel Theorem and further it will lead to the growth of complexity because people start to build logical and then physical explanations of the exceptions they encounter. Hence it will lead to the loop in the mind logical processes depicted above. In other words, there will be no evolution of people’s conscience.

From the discussions it follows that the visible world is Arithmetic. This is due to Godel Theorem existence. It shows that one can not build another arithmetic inside arithmetic. One can not build the same thing inside the thing.

When it is understood well, then there will be a contact of civilizations.

Theorem P shows that up-and-down method is the only method that can “hear” any signal. It is very simple and requires no investments. So, it is the only method that gives a possibility to fulfill formula (A).

Using up-and-down method in contacting other civilization one needs to take into account the results from [4] which state that up-and-down method with small number of samples is not not able to preserve the amplitude of the input signal, ie small number of samples “do not hear” well other civilization. This problem is fixed with the bigger number of samples.
References