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Possibility of Hypercomputation from the Standpoint of Superluminal Particles

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Abstract

In mathematics and computer science, an accelerated Turing machine is a hypothetical computational model related to Turing machines, which can perform the countable infinite number of computational steps within a finite time. But this machine cannot be physically realized from the standpoint of the Heisenberg uncertainty principle, because the energy required to perform the computation will be exponentially increased when the computational step is accelerated and it is considered that it is mere a mathematical concept and there is no possibility for its realization in a physical world. However, by using superluminal particles instead of subluminal particles including photons, it can be shown that the hypercomputation system which can perform infinite steps of computation within a finite time length and energy can be realized.

Keywords: Turing machine, Zeno machine, hypercomputation, superluminal particle, tachyon, halting problem.
2010 MSC: 68Q05, 81P68, 83A05.

1. Introduction

In mathematics and computer science, an accelerated Turing machine is a hypothetical computational model related to Turing machines which can perform the countable infinite number of computational steps within a finite time. It is also called a Zeno machine which concept was proposed by B. Russel, R. Blake and H. Weyl independently, which performs its first computational step in one unit of time and each subsequent step in half the time of the step before, that allows an infinite number of steps can be completed within a finite interval of time (Ord, 2006), (Hamkins & Lewis, 2000). However this machine cannot be physically realized from the standpoint of the Heisenberg uncertainty principle $\Delta E \cdot \Delta t \approx \hbar$, because the energy to perform the computation will be exponentially increased when the computational step is accelerated. Thus it is considered that the Zeno machine is mere a mathematical concept and there is no possibility to realize it in

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a physical world. Contrary to this conclusion, the author studied the possibility to realize it by utilizing superluminal particles instead of subliminal particles including photons.

2. Computational time required to perform infinite steps of computation by using ordinary particles

Feynman defined the reversible computer model as shown in Fig.1, which requires energy per step given by (Feynman, 2000):

$$\text{energy per step} = k_B T \frac{f-b}{(f+b)/2} \quad , \tag{2.1}$$

where k_B is Boltzmann's constant, T is a temperature, f is a forward rate of computation and b is backward rate.

Supposing that there in no energy supply and parameters f and b are fixed during the computation, we can consider the infinite computational steps given by:

$$E_1 = kE_0,\ E_2 = kE_1, \cdots, E_n = kE_{n-1}, \cdots, \tag{2.2}$$

where we let the initial energy of computation be $E_0 = k_B T$, $k = 2(f-b)/(f+b)$ and E_n is the energy for the n-th step computation.

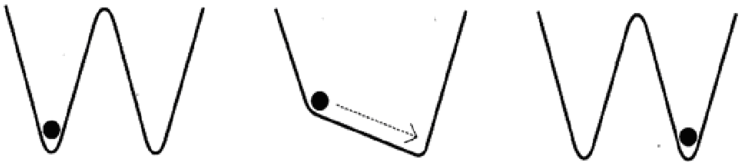

Figure 1. Computational steps for the reversible computation (Feynman, 2000).

From which, we have $E_n = k^n E_0$, then the energy loss for each computational step becomes:

$$\begin{aligned} \Delta E_1 = E_0 - E_1 &= (1-k)E_0 \\ \Delta E_2 = E_1 - E_2 &= (1-k)kE_0 \\ &\vdots \\ \Delta E_n = E_{n-1} - E_n &= (1-k)k^{n-1}E_0. \end{aligned} \tag{2.3}$$

According to the paper by (Lloyd, 2000), it is required for the quantum system with average energy ΔE to take time at least Δt to evolve to an orthogonal state given by:

$$\Delta t = \frac{\pi\hbar}{2\Delta E}, \tag{2.4}$$

From which, the total energy for the infinite steps yields E_0 if setting $E = \Delta E_i$ in equation (2.4), then the total time for the computation with infinite steps becomes:

$$T_n = \sum_{j=1}^{n} \Delta t_n = \frac{\pi\hbar}{2E_0} \sum_{j=1}^{n} \frac{1}{(1-k)k^{j-1}}. \tag{2.5}$$

As the infinite sum of equation (2.5) diverges to infinity as shown in Fig. 2, the Feynman model of computation requires infinite time to complete the calculation when satisfying $0 < k < 1$.

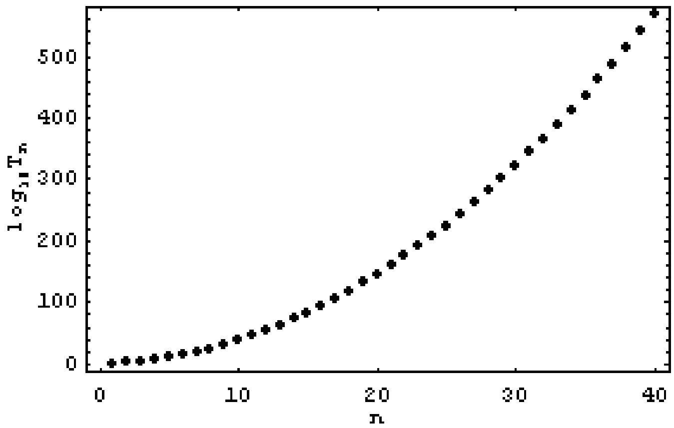

Figure 2. Computational time to complete the n-th step of computation by using subluminal particles (for the case, $k = 1/2\,, \gamma = 1.0$).

Hence it can be seen that a computer system utilizing subluminal particles including photons requires infinite time to complete infinite steps of computation.

3. Computational time by using superluminal elementary particles

3.1. Uncertanity Principle for superluminal particles

E. Recami claimed in his paper (Recami, 2001) that tunneling photons which travel in evanescent mode can move with superluminal group speed inside the barrier. Chu and S. Wong at AT&T Bell Labs measured superluminal velocities for light traveling through the absorbing material (Brown, 1995). Furthermore Steinberg, Kwait and Chiao measured the tunneling time for visible light through the optical filter consisting of the multilayer coating about 10^{-6} m thick. Measurement results by Steinberg and co-workers have shown that the photons seemed to have traveled at 1.7 times the speed of light (Steinberg *et al.*, 1993). Recent optical experiments at Princeton NEC have verified that superluminal pulse propagation can occur in transparent media (Wang *et al.*, 2000). These results indicate that the process of tunneling in quantum physics is superluminal as claimed by E. Recami. From relativistic equations of energy and momentum of the moving particle, shown as:

$$E = \frac{m_0 c^2}{\sqrt{1 - v^2/c^2}}, \tag{3.1}$$

and

$$p = \frac{m_0 v}{\sqrt{1 - v^2/c^2}}\,, \tag{3.2}$$

the relation between energy and momentum can be shown as $p/v = E/c^2$.

From which, we have (Musha, 2012):

$$\frac{v\Delta p - p\Delta v}{v^2} = \frac{\Delta E}{c^2}\,, \tag{3.3}$$

Supposing that $\Delta v/v^2 \approx 0$, equation (3.3) can be simplified as:

$$\Delta p \approx \frac{v}{c^2}\Delta E\,. \tag{3.4}$$

This relation is also valid for the superluminal particle called a tachyon which has an imaginary mass im_* (Musha, 2012), the energy and the momentum of which are given by following equations, respectively.

$$E = \frac{m_* c^2}{\sqrt{v^2/c^2 - 1}}\,, \tag{3.5}$$

$$p = \frac{m_* v}{\sqrt{v^2/c^2 - 1}}\,. \tag{3.6}$$

According to the paper by M. Park and Y. Park (Park & Park, 1996), the uncertainty relation for the superluminal particle can be given by:

$$\Delta p \cdot \Delta t \approx \frac{\hbar}{v - v'}\,, \tag{3.7}$$

where v and v' are the velocities of a superluminal particle after and before the measurement. By substituting equation (3.4) into (3.7), we obtain the uncertainty relation for superluminal particles given by:

$$\Delta E \cdot \Delta t \approx \frac{\hbar}{\beta(\beta - 1)}\,, \tag{3.8}$$

when we let $v' = c$ and $\beta = v/c$.

3.2. Computational time required for the superluminal particle

Instead of subluminal particles including photons, the time required for the quantum system utilizing superluminal particles becomes

$$T_n = \sum_{j=1}^{n} \Delta t_j = \frac{\pi\hbar}{2E_0}\sum_{j=1}^{n}\frac{1}{\beta_j(\beta_j - 1)(1-k)k^{j-1}}\,, \tag{3.9}$$

from the uncertainty principle for superluminal particles given by equation (3.8), where β_j can be given by:

$$\beta_j = \sqrt{1 + \frac{{m_*}^2 c^4}{{E_j}^2}} = \sqrt{1 + \frac{\gamma^2}{k^{2j}}}\,, \tag{3.10}$$

which is derived from equation (3.6), where $\gamma = m_* c^2/E_0$.

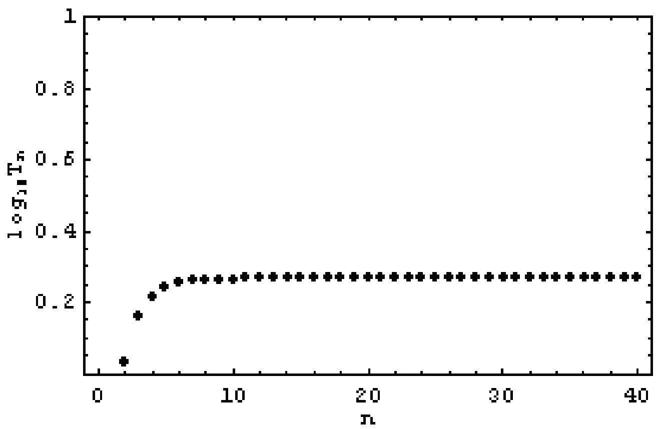

Figure 3. Computational time to complete the n-th step of computation by using superluminal particles (for the case, $k = 1/2$, $\gamma = 1.0$).

Hence it is seen that the computation time can be accelerated according to equation (3.10).

By the numerical calculation, it can be shown that the infinite sum of equation (3.9) converges to a certain value satisfying $0 < k < 1$ as shown in Fig.4.

In this figure, the horizontal line is for the parameter $\gamma = m_* c^2/E_0$ and the vertical line is for the time to complete infinite step calculations. From these calculation results, an accelerated Turing machine can be realized by utilizing superluminal particles instead of subliminal particles for the Feynman's model of computation.

Thus, contrary to the conclusion for the Feynman's model of computation by using ordinary particles, it can be seen that superluminal particles permits the realization of an accelerated Turing machine.

It is known that an accelerate Turing machines allow us to be computed some functions which are not Turing-computable such as the halting problem (Kieu, 2004), described as "given a description of an arbitrary computer program, decide whether the program finishes running or continues to run forever".

This is equivalent to the problem of deciding, given a program and an input, whether the program will eventually halt when run with that input, or will run forever.

Halting problem for Turing machines can easily solved by an accelerated Turing machine using the following pseudocode algorithm (as shown in Fig.5). As an accelerated Turing machines are more powerful than ordinary Turing machines, they can perform computation beyond the Turing limit which is called hypercomputation, such as to decide any arithmetic statement that is infinite

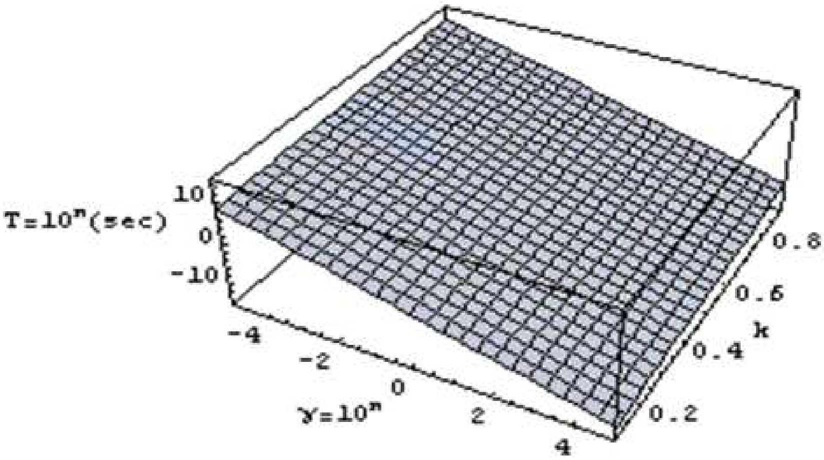

Figure 4. Computational time by using superluminal particles.

```
begin program
  write 0 on the first position of the output tape;
  begin loop
    simulate 1 successive step of the given Turing
    machine on the given input;
    if the Turing machine has halted, then write 1 on
    the first position of the output tape and break out
    of loop;
  end loop
end program
```

Figure 5. Psedocode algorithm to solve the halting problem (Wikipedia, 2009).

time decidable. From this result, we can construct an oracle machine (van Melkebeek, 2000) by using a superluminal particle, which is an abstract machine used to study decision problems. It can be conceived as a Turing machine with a black box, called an oracle, which is able to decide certain decision problems in a single operation.

4. Human mind from the standpoint of superluminal hyper computation

There are some papers on the hypothesis that the human mind is consisted of evanescent tunneling photons which has a property of superluminal particles called tachyons (Georgiev, 2003), (Musha, 2005, 2009).

Professor Dutheil proposed his hypothesis in his book titled, ”L’homme superlumineux” (Dutheil

& Dutheil, 2006), that consciousness is a field of superluminal matter belonging to the true fundamental universe shown in Fig.6, and our world is merely a subluminal holographic projection of it.

He proposed the hypothesis based on superluminal consciousness shown as follows;

- The brain is nothing more than a simple computer that transmit information.
- Consciousness, or the mind is composed of a field of tachyons or superluminal matter, located on the other side of the light barrier in superluminal space-time.

If the human consciousness is consisted of superluminal particles as claimed by Prof. Dutheil, the superiority of the human brain to conventional silicon processors may be explained because it can perform infinite steps of computation within a finite time.

To further interpret this result, we consider S.Berkovich suggestion of a ”cloud computing paradigm”, in which is given an elegant constructive solution to the problem of the organization of mind. Within his article, he defines a situation where individual brains are not stand-alone computers but collective users whom have shared access to portions of a holographic memory of the Universe (Berkovich, 2010). He proposed that the cosmic background radiation (CMB) has nothing at all to do with the residual radiation leftover from the Big Bang.

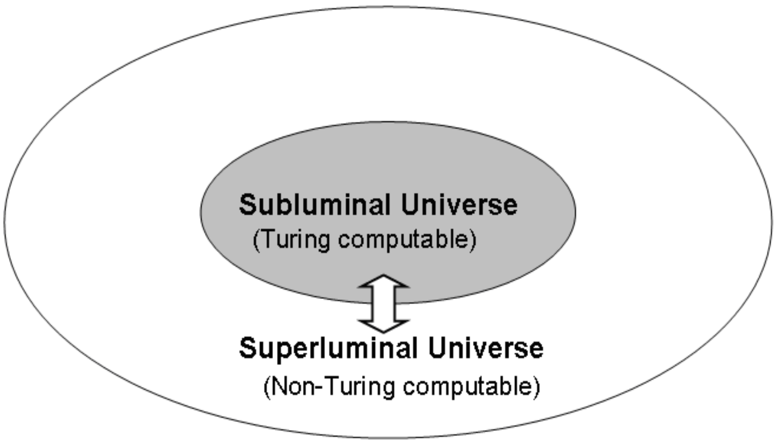

Figure 6. Superluminal Universe model proposed by Prof. Dutheil.

Instead, he claimed that CMB is nothing but noise from writing operations in the holographic memory of the Universe. Such holographic write operations would require some type of universal clocking rate for these operations. Since the virtual superluminal particle pairs are created and annihilated in the vacuum within a short, finite period of time according to the uncertainty principle, we could logically consider this duration as the clock rate for these operations (Fig.7).

From this standpoint, the extraordinary capability of a human brain such as the enigma of Srinivasa Ramanujan (Kanigel, 1991), who invented numerous remarkable and mysterious mathematical formulas from his inspiration without proofs, can be explained from the capability of superluminal consciousness which is superior to that of conventional Turing type computer systems.

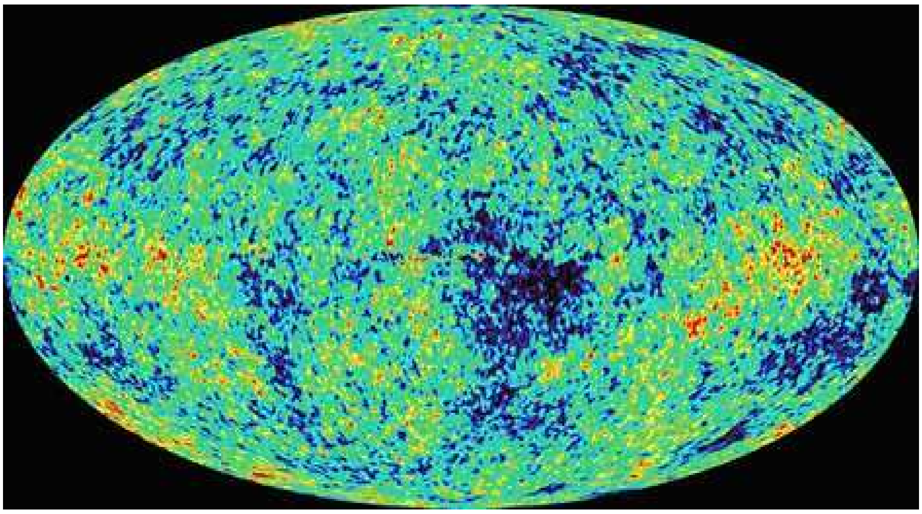

Figure 7. Is CBR an activity of zero-point energy fluctuations of vacuum which relates to the writing operations in the holographic memory of the Universe? (www.computus.org).

5. Conclusion

From the theoretical analysis, it is seen that a hypercomputational system which can complete infinite steps of computation within a finite time and energy can be realized by using superluminal particles from the standpoint of quantum mechanics. Thus an extraordinary capability of human consciousness such as intuition compared with the ordinary silicon processors might be explained if they are composed of superluminal particles, because they have a capability to function beyond the ordinary Turing machines.

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