Traveling Exchanger Problem and Manually-operated Quantum Computer (MoQC)

Kotaro Sato (Satory Design)

Submitted on 1 April 2020

Abstract

Quantum computers using qubits have the potential to perform general-purpose calculations at very high speeds. However, we believe that computers based on other principles can be proposed to solve specific problems. The Traveling Exchanger Problem (TEP) is similar to the Traveling Salesman Problem (TSP), except that the exchange fee is multiplied instead of adding distance. We used the property that multiplication using two polarizing plates is determined only by the local difference between the inclinations. In general, the development of a practical quantum computer is very expensive and could not be made for less than US$ 50 per unit. Here, we showed a low-cost computer that applies the properties of quantum mechanics to solve the TEP. As a result, the route that the exchanger could minimize the payment of fees was shown optically.

● What is Traveling Exchanger Problem (TEP) ?

A traveler travels between countries. He starts traveling from one country (A) and must enter all countries (B, C and D) (Fig. 1). Every time he crosses the border, he exchanges all money for the country's currency. He is charged with a fee when he exchanges money. Finally, he does not need to return to his departure country. Find the route that minimizes commission payments.

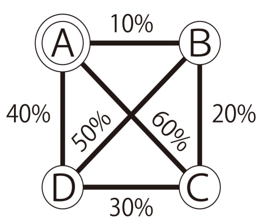

FIG. 1. Sample of exchange fee of TEP

● Experimental Device Structure

Light from the LED is photographed by a digital camera through three polarizing plates (Fig. 2). Although the polarizing plate 1 is fixed, the polarizing plates 2 and 3 can be freely rotated. The LED and polarizing plate 1 can be replaced with the iPad.

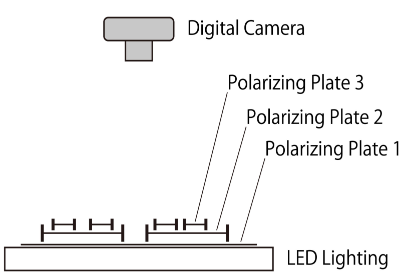

FIG. 2. Structure of the MoQC (Sectional view)

● Multiplication by Polarizer

In Fig. 3, the light intensity is the transmission probability of a photon. The probability, or multiplier, can be adjusted by rotating the polarizing plate by hand. As a result of the experiment, the linearity of the measured brightness in the real image was higher in $\cos^{-1}(L)$ than in $\cos^{-1}(\sqrt{L})$, which is theoretically considered correct. We chose the former because we only needed to be able to compare brightness.

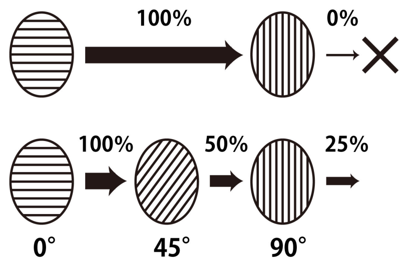

FIG. 3. Multiplication by polarizing plates

L	$\cos^{-1}(\sqrt{L})$	$\cos^{-1}(L)$
0.0	90.00	90.00
0.1	71.57	84.26
0.2	63.43	78.46
0.3	56.79	72.54
0.4	50.77	66.42
0.5	45.00	60.00
0.6	39.23	53.13
0.7	33.21	45.57
0.8	26.57	36.87
0.9	18.43	25.84
1.0	0.00	0.00

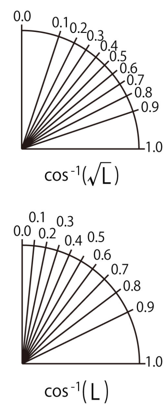

FIG. 4. Multiplier L , and angle between two polarizers

In case of Fig. 1, there are six routes in total. Theoretical values are as follows :

- Route 1 (R1) : A→B→C→D 0.9×(0.8×0.7) = 0.504
- Route 2 (R2) : A→B→D→C 0.9×(0.5×0.7) = 0.315
- Route 3 (R3) : A→C→B→D 0.4×(0.8×0.5) = 0.16
- Route 4 (R4) : A→C→D→B 0.4×(0.7×0.5) = 0.14
- Route 5 (R5) : A→D→B→C 0.6×(0.5×0.8) = 0.24
- Route 6 (R6) : A→D→C→B 0.6×(0.7×0.8) = 0.336

Since the last country to be visited is automatically determined, the values in parentheses are collectively set to the polarizing plate 3.

The experimental results (Fig. 5) showed that R1 is the brightest and the correct answer. On the other hand, there is no difference between R2 and R6 due to lack of accuracy.

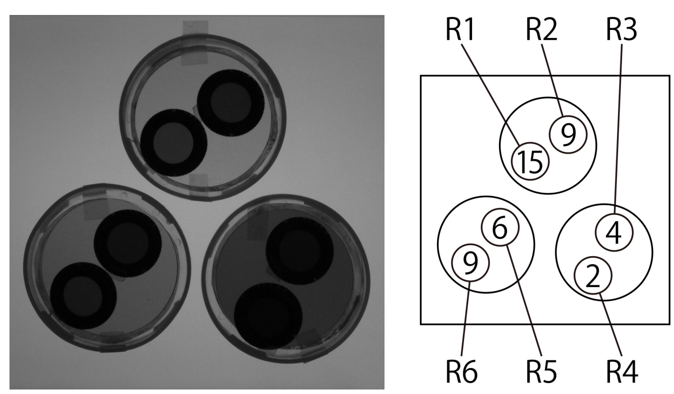

FIG. 5. Calculation result image (average brightness [%])