jild. 3 No 2 (2026)

MANAGEMENT AND ECONOMICS SCIENTIFIC RESEARCH JOURNAL

MENEJMENT VA IQTISODIYOT ILMIY-TADQIQOT JURNALI

НАУЧНО-ИССЛЕДОВАТЕЛЬСКИЙ ЖУРНАЛ МЕНЕДЖМЕНТА И ЭКОНОМИКИ

journals@timeedu.uz

+998 95 651 90 00

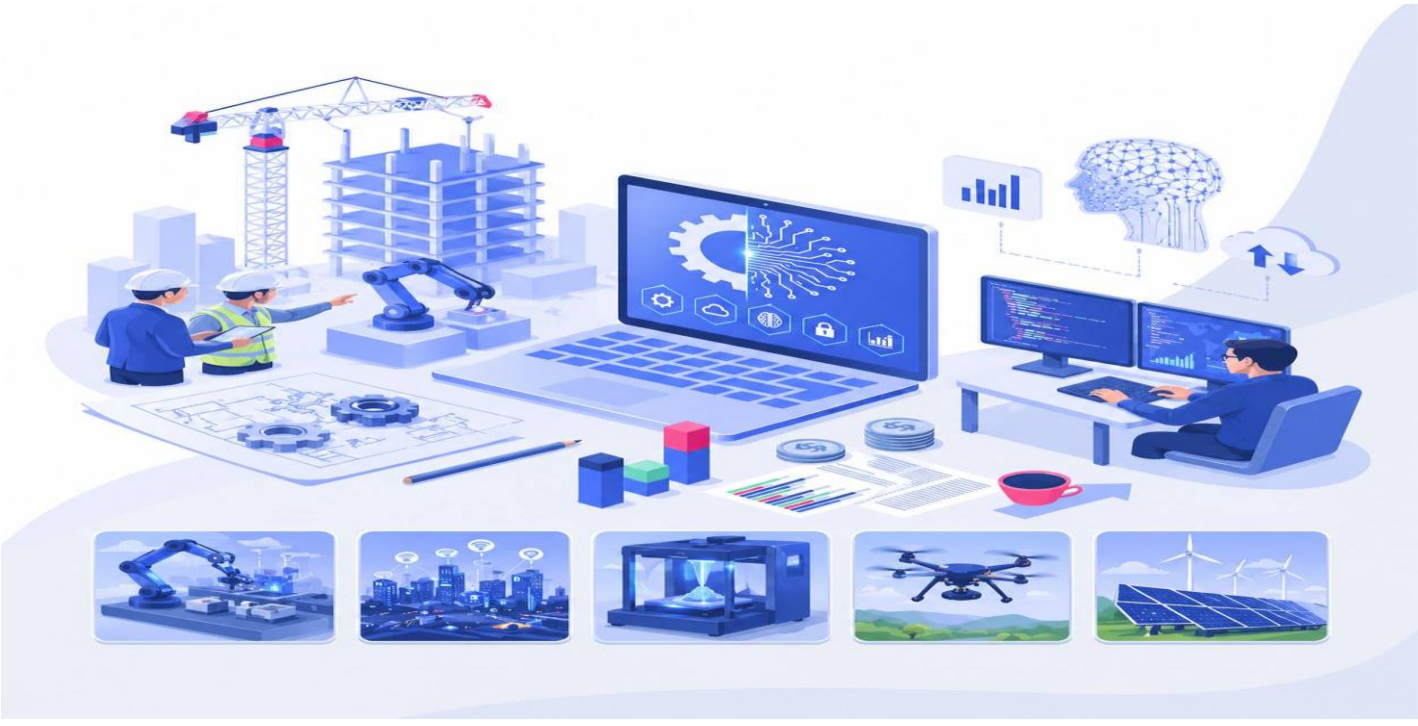
O‘ZBEKISTON RESPUBLIKASI

OLIY TA’LIM, FAN VA INNOVATSIYALAR VAZIRLIGI

TOSHKENT MENEJMENT VA IQTISODIYOT INSTITUTI

“MUHANDISLIKDA SUN’IY INTELLEKT VA RAQAMLI INNOVATSION TEXNOLOGIYALAR: ZAMONAVIY YECHIMLAR VA ISTIQBOLLAR” MAVZUSIDAGI

XALQARO ILMIY-AMALIY ANJUMAN MATERIALLARI



FARG‘ONA-2026

O'ZBEKISTON RESPUBLIKASI OLIY TA‘LIM, FAN VA INNOVATSIYALAR VAZIRLIGI

TOSHKENT MENEJMENT VA IQTISODIYOT INSTITUTI

“MUHANDISLIKDA SUN’IY INTELLEKT VA RAQAMLI INNOVATSION TEXNOLOGIYALAR: ZAMONAVIY YECHIMLAR VA ISTIQBOLLAR” MAVZUSIDAGI

XALQARO ILMIY-AMALIY ANJUMAN MATERIALLARI

21 MAY 2026 YIL

МИНИСТЕРСТВО ВЫСШЕГО ОБРАЗОВАНИЯ, НАУКИ И ИННОВАЦИЙ РЕСПУБЛИКИ УЗБЕКИСТАН

ТАШКЕНТСКИЙ ИНСТИТУТ УПРАВЛЕНИЯ И ЭКОНОМИКИ

МЕЖДУНАРОДНАЯ НАУЧНО-ПРАКТИЧЕСКАЯ КОНФЕРЕНЦИЯ НА ТЕМУ «ИСКУССТВЕННЫЙ ИНТЕЛЛЕКТ И ЦИФРОВЫЕ ИННОВАЦИОННЫЕ ТЕХНОЛОГИИ В ИНЖЕНЕРИИ: СОВРЕМЕННЫЕ РЕШЕНИЯ И ПЕРСПЕКТИВЫ»

21 МАЯ 2026 ГОДА

MINISTRY OF HIGHER EDUCATION, SCIENCE AND INNOVATIONS OF THE REPUBLIC OF UZBEKISTAN

TASHKENT INSTITUTE OF MANAGEMENT AND ECONOMICS

INTERNATIONAL SCIENTIFIC AND PRACTICAL CONFERENCE ON THE THEME "ARTIFICIAL INTELLIGENCE AND DIGITAL INNOVATIVE TECHNOLOGIES IN ENGINEERING: MODERN SOLUTIONS AND PROSPECTS" 21 MAY 2026

“Muhandislikda sun’iy intellekt va raqamli innovatsion texnologiyalar: zamonaviy yechimlar va istiqbollar” Xalqaro ilmiy-amaliy anjuman tezislar to‘plami. 2026-yil 21-may.

Ushbu to‘plamda — “Muhandislikda sun’iy intellekt va raqamli innovatsion texnologiyalar: zamonaviy yechimlar va istiqbollar” Xalqaro ilmiy –amaliy anjuman ishtirokchilarining tezislari keltirilgan. Anjuman kun tartibiga kiritilgan masalalar dolzarb bo‘lib, u yalpi ma‘ruzalar va amaliy zamonaviy muhandislik ta’limida raqamli transformatsiya va sun’iy intellekt, muhandislik yechimlari va sanoat 4.0, robototexnika va avtomatlashtirilgan boshqaruv tizimlari, kiberxavfsizlik va ma'lumotlarni himoya qilish, ta’limda axborot va innovatsion texnologiyalarning qo‘llanilishi, biznes jarayonlar va raqamli iqtisodiyotga axborot texnologiyalarining o‘rni kabi sho‘balardan tashkil topgan. To‘plam sohasi mutaxassislari, ilmiy tadqiqotchilar, professor-o‘qituvchilar, doktorantlar, magistrlar va talabalar uchun mo‘ljallangan.

Maqolalarda keltirilgan ma‘lumotlarning haqqoniyligi uchun mualliflar mas‘uldir.

MANAGEMENT AND ECONOMICS
SCIENTIFIC RESEARCH JOURNAL

+998 95 651 90 00
journals@timeedu.uz
Shota Rustaveli ko'chasi, 114
tmijournals.ndc-agency.uz
TMII_ilmiy_bolim

Tahririyat jamoasi

4-SHO‘BA: KIBERXAVFSIZLIK VA MA'LUMOTLARNI HIMOYA QILISH

OPTIMIZING GLOBAL SEARCH PROBLEMS USING GROVER'S QUANTUM ALGORITHM

Sh.A.Toirov, A.A.Seytnazarova, T.E.Xudoyqulov
Tashkent Institute of Management and Economics

Abstract. *The study examines the use of Grover's quantum algorithm to optimize global search problems, demonstrating its quadratic speedup over classical methods for improved efficiency. The research tackles practical challenges, including quantum noise, scalability, and resource constraints, by proposing innovative solutions. The techniques developed integrate quantum search principles into large-scale optimization tasks across diverse fields. This work lays a foundational framework for applying quantum algorithms to solve complex scientific and industrial problems.*

Key words. *the quantum algorithm, Grover’s method, global optimization, intellectual management.*

Annotatsiya. Tadqiqot global qidiruv muammolarini optimallashtirish uchun Groverning kvant algoritmidan foydalanishni o'rganadi va samaradorlikni oshirish uchun klassik usullarga nisbatan kvadratik tezligini namoyish etadi. Tadqiqot innovatsion echimlarni taklif qilish orqali amaliy muammolarni, jumladan kvant shovqini, miqyoslilik va resurslarni cheklashni hal qiladi. Ishlab chiqilgan texnikalar kvant qidirish tamoyillarini turli sohalardagi keng ko'lamli optimallashtirish vazifalariga birlashtiradi. Ushbu ish murakkab ilmiy va ishlab chiqarish muammolarini hal qilish uchun kvant algoritmlarini qo'llash uchun asos yaratadi.

Kalit so'zlar. kvant algoritmi, Grover usuli, global optimallashtirish, intellektual boshqaruv.

Аннотация. В исследовании рассматривается применение квантового алгоритма Гровера для оптимизации задач глобального поиска, демонстрируя его квадратичное ускорение по сравнению с классическими методами для повышения эффективности. В работе решаются практические задачи, включая квантовый шум, масштабируемость и ограничения ресурсов, путем предложения инновационных решений. Разработанные методы интегрируют принципы квантового поиска в крупномасштабные задачи оптимизации в различных областях. Эта работа

закладывает фундаментальную основу для применения квантовых алгоритмов для решения сложных научных и промышленных задач.

Ключевые слова: квантовый алгоритм, метод Гровера, глобальная оптимизация, интеллектуальное управление.

Introduction

It is becoming more crucial in the world to learn quantum algorithm, and to improvise, develop and introduce the methods and algorithms of solving problems by these algorithms. Nowadays, the tasks solved by quantum algorithms are generating more efficient results than the problems that are solved using other algorithms [1]. At present, special attention is paid to the analytical analysis of mathematical models of these algorithms and the creation of quantum computers that run on the basis of quantum algorithms. In quantum computing (quantum algorithms) the quality (feature) of the process that is being studied is determined as a result of direct parallel calculations [2]. In addition, the solution of the problems that are difficult to solve or for the ones that are not possible to be solved algorithmically by traditional (classic) methods.

Although Grover's algorithm is generally considered useful for database searching, the basic ideas underlying this algorithm are applicable in a much broader context. This approach is used to speed up search algorithms that can build a "quantum oracle" that separates the needle from the haystack. It uses the term ancilla (Ancilli are extra bits used to achieve specific computational goals (such as in reversible computation)) or auxiliary qubit (ancilla qubit) to refer to some additional qubits used by an algorithm.

Main body

This algorithm searches through $N = 2^n$ an unordered set of elements in order to find the element that satisfies some conditions. Currently, while the best classical search algorithm on unstructured data takes time $O(N)$, Grover's algorithm allows for a quadratic speedup of search on a quantum computer in operations just $O\left(\sqrt{N}\right)$ [22].

Grover's search algorithm is considered to be one of the best methods of quantum algorithms, and it shows that when the classical algorithms of quantum system is used, it depends on the slowness of operation time, and that it can be used in order to improve its quality. In this case, in order to reach a high speed, Grover's algorithm bases on the quantum super-position of the processes [7]. As numerous quantum algorithms, Grover's algorithm also sets off by putting n qubit registers of the machine into the super-position that is equal to all the possible 2^ncases [8]. It is important to remember that the amplitude associated

with each possible configuration of each qubit is equal to $\frac{1}{\sqrt{2^n}}$ and the probability of being of the 2^n state of the system in any state is equal to $\frac{1}{2^n}$. All these possible states correspond to all possible entries in the database of Grover's algorithm, and therefore, starting with a given amplitude assigned to each element in the search space, each element is considered simultaneously in quantum superposition and amplitudes are controlled from there [9].

Along with the superposition of states, Grover's algorithm belongs, in general, to the family of quantum algorithms that use amplitude amplifiers, which take the advantage of quantum amplitudes that distinguish amplitudes from probabilities. The key to these algorithms is a selective displacement of one state of quantum system, of its space that satisfy some kind of condition in each iteration. These amplitude amplifier algorithms are so unique to quantum calculating that such feature of amplitudes has no parallel in classical probabilities [11].

Methods

Grover's algorithm utilizes a quantum register composed of n - qubits, where n is the number of qubits required to represent a search space of size $N = 2^n$. Initially, all qubits are set to the ground state $|0\rangle$:

$$|0\rangle^{\otimes n} = |0\rangle \tag{1}$$

The algorithm begins by generating an equal superposition of all possible states. This is achieved using the Hadamard transformation $H^{\otimes n}$, which applies a Hadamard gate to each qubit. The resulting state can be mathematically expressed as:

$$|\psi\rangle = H^{\otimes n}|0\rangle^{\otimes n} = \frac{1}{\sqrt{2^n}}\sum_{x=0}^{2^n-1}|x\rangle \tag{2}$$

Once the system is in superposition, the algorithm proceeds with a series of Grover iterations [23]. These iterations involve two main operations: phase inversion via the quantum oracle O and amplitude amplification. The number of Grover iterations required to amplify the probability of the correct state to its maximum is approximately $\frac{\pi}{4}\sqrt{2^n}$. This process ensures that the probability of observing the correct state becomes optimal after the total rotation of the state space by $\frac{\pi}{4}$ [23]. The quantum oracle O serves as a black-box function that marks the desired solution state. If the system is in the correct state, the oracle applies a phase shift of π, effectively flipping the sign of the corresponding amplitude. Mathematically, this action is described as:

$$|x\rangle \xrightarrow{O} (-1)^{f(x)}|x\rangle \tag{3}$$

Here, $f(x)=0$. The exact implementation of $f(x)$ is a function that evaluates to 1 for the correct solution and 0 otherwise. The oracle does not disturb the system when it is not in the target state but ensures that the marked state becomes identifiable during subsequent amplitude amplification. [23].

Results

Mathematical solutions of the above-mentioned information through a and the oracle accepts values between 0 and 32. The next step is to consider the case where $N=32=2^5$ is equal, and the desired state x_0 is represented by a string of 11110 bits [22].

To describe this process, $n=5$ consists of qubits, i.e.

$$|x\rangle=\alpha_0|00000\rangle+\alpha_0|00001\rangle+.....+\alpha_{31}|11111\rangle$$

where a_i - $|i\rangle$ is the amplitude of the state. Grover's algorithm starts from system 0

$$1|00000\rangle$$

and then the Hadamard transform is applied to obtain an equal amplitude associated with each state $\frac{1}{\sqrt{N}}=\frac{1}{\sqrt{32}}=\frac{1}{4\sqrt{2}}$ so that the solution to the problem is equal to the probability of being in one of the 32 possible states.

$$H^5|00000\rangle=\frac{1}{4\sqrt{2}}|00000\rangle+\frac{1}{4\sqrt{2}}|00001\rangle+.....+\frac{1}{4\sqrt{2}}|11111\rangle=\frac{1}{4\sqrt{2}}\sum_{x=0}^{31}|x\rangle=\psi$$

Three Grover iterations are sufficient to solve the problem, i.e. $\frac{\pi}{4}\sqrt{N}=\frac{\pi}{4}\sqrt{32}=\sqrt{2}\pi\approx 4,4$, which turns up to 4 iterations.

At each iteration, the quantum oracle *O* must first be invoked, followed by an inversion by averaging or diffusion transformation. The oracle query negates the condition amplitude $|x_0\rangle$ in which case $|11110\rangle$ gives the configuration [22].

$$|x\rangle=\frac{1}{4\sqrt{2}}|00000\rangle+\frac{1}{4\sqrt{2}}|00001\rangle+.....-\frac{1}{4\sqrt{2}}|11110\rangle+\frac{1}{4\sqrt{2}}|11111\rangle$$

The above mathematical solutions are based on the results obtained after executing the program on a classical computer using a quantum algorithm. First, the program creates a superposition state [23].

[[0.1767767]
[0.1767767]
[0.1767767]
...
[0.1767767]
[0.1767767]
[0.1767767]]

Second, the oracle O determines the maximum $|\psi\rangle$

And so, $O|\psi\rangle^{Q(t)} = (-1)^{f(x)}|\psi\rangle^{Q(t)}$ when applied, the following superposition condition is obtained:

[[0.1767767]
[0.1767767]
...
[0.1767767]
[-0.1767767]
[0.1767767]
[0.1767767]]

This second step indicates the number of repetitions given. Grover's maximum number of repetitions is calculated as follows:

$$\frac{\pi}{4}\sqrt{2^n}$$

$_n$ the number of qubits or the length of the quantum chromosome, so $n=5$in the example of the function described in the problem [18].

As a result of repeating the second step

[[0.15467961]
...
[0.15467961]
[-0.508233]
[0.15467961]
[0.15467961]
[0.15467961]]

In the third step, the oracle O determines the maximuml $|\psi\rangle$ and the following results are obtained as a result of iteration.

Fourth and last, Grover's diffusion operator locates the chromosome with the specified state at $|\psi\rangle^{Q(t)}$. Therefore, the following process $|\psi\rangle^{Q(t)} = G|\psi\rangle^{Q(t)}$ execution results [18-19].

[[0.11324757]
[0.11324757]
...
[0.11324757]
[-0.77616018]
[0.11324757]
[0.11324757]
[0.11324757]]

In the next step, we get the result

[[0.05765959]
[0.05765959]

...
[0.94706733]
[0.05765959]
[0.05765959]
[0.05765959]]

Finally, $|\psi\rangle^{Q(t)}$ when done, the state pointed to by the maximum chromosome is obtained.

That is, the state of the quantum algorithm $_{|30\rangle}$, chromosome $_{|11110\rangle}$ and the objective function $_{|1671\rangle}$ will be equal to [24].

Discussion

As you can see from Figure 1 in this article, solving the problem leads to four iterations of Grover's iteration, i.e., $\frac{\pi}{4}\sqrt{N} = \frac{\pi}{4}\sqrt{32} = \sqrt{2}\pi \approx 4,4$, which goes up to 4 iterations. At each iteration, it first uses the quantum oracle O, and then performs an inversion on the average or diffusion transform. It is clear from the process of solving the problem mathematically that Grover's algorithm makes it easier to reach the solution by increasing the amplitude. That is, in our problem, the optimal solution of the given function is considered to be 0.94.

The problems for which quantum algorithms can be potentially used:

a) effective calculating the number of the solutions to given search problem;
b) speeding up NP problems;
c) speeding up the search of keys in cryptosystems [3];
d) finding the shortest way [7];
e) searching or analyzing necessary data in unordered databases [6].

Grover's algorithm is more likely to get a correct answer than a wrong answer, when the input size is $N = 2^n$, the error only decreases with the input size. Even though Grover's algorithm is probabilistic, the error gets negligible as N gets larger[23].

REFERENCES

1. Goldberg D.E. *Genetic Algorithms in Search, Optimization, and Machine Learning.* Addison-Wesley: Reading, MA, USA, pp. 1-432 (2000).
2. Lahoz-Beltra R. *Bioinformatica: Simulacion, Vida Artificial e Inteligencia Artificial.* Ediciones Diaz de Santos: A Coruna, Spain, pp. 237-323 (2004). (In Spanish)
3. Perales-Gravan C., Lahoz-Beltra R. An AM radioreceiver designed with a genetic algorithm based on a bacterial conjugation genetic operator. *IEEE Trans. Evolut. Comput.* 12, pp.129-142 (**2008**).

4. Ribeiro Filho J.L., Treleaven P.C., Alippi C. Genetic-algorithm programming environments. *IEEE Comput. 24,* pp. 28-43 (1994).
5. Feynman R.P. Simulating physics with computers. *Int. J. Theor. Phys.* 21, 467-488 (2001).
6. Fraser A.S. Simulation of genetic systems by automatic digital computers. *Aust. J. Biol. Sci.* 10,484^91 (**1990**).
7. Han K.-H., Kim J.-H. Quantum-inspired evolutionary algorithm for a class of combinatorial optimization. *IEEE Trans. Evolut. Comput.* 6, pp. 580-593 (**2002**).
8. Ying M. Quantum computation, quantum theory and AI. *Artif. Intell.* 174,162-176 (**2010)**.
9. Lahoz-Beltra R. University of Stirling, Computing Science and Mathematics School of Natural Sciences, Stirling, Scotland, United Kingdom. Quantum Genetic Algorithms for Computer Scientists. Computing Science Seminars, Spring 2015, 26 June. Personal communication, (2015).
10. Susskind L., Friedman A. *Quantum Mechanics: The Theoretical Minimum;* Penguin Books: London, UK. pp. 1-364 (2015).
11. Boghosian B.M., Taylor W. Simulating quantum mechanics on a quantum computer. *Phys. D* 120, pp. 30-42 (**2002)**.
12. Alfonseca M., Ortega A., de La Cruz M., Hameroff S.R., Lahoz-Beltra R. A model of quantum-von Neumann hybrid cellular automata: Principles and simulation of quantum coherent superposition and decoherence in cytoskeletal microtubules. *Quantum Inf. Comput. 15,* pp. 22-36 (**2015)**.
13. Zeiter D. A Graphical Development Environment for Quantum Algorithms. Master's Thesis, Department of Computer Science, ETH Zurich, Zurich, Switzerland, 3 September 2008.
14. QCAD: GUI Environment for Quantum Computer Simulator. Available online: http://qcad.osdn.jp/ (accessed on 25 April 2016).
15. jQuantum-Quantum Computer Simulation Applet. Available online: http://jquantum.sourceforge.net/ jQuantumApplet.html (accessed on 25 April 2016).
16. Hayes B. Programming your quantum computer. *Am. Sci. 102,* pp.22-25 (**2014)**.
17. QCL-A Programming Language for Quantum Computers. Available online: http://tph.tuwien.ac.at/ ~oemer/qcl.html (accessed on 25 April 2016).
18. Al Daoud E. Quantum computing for solving a system of nonlinear equations over GF(q). *Int. Arab J. Inf. Technol. 4,* pp.201-205 (2007).
19. Lahoz-Beltra R. Simple genetic algorithm (SGA). Figshare (2016).

20. Lahoz-Beltra R. Perales-Gravan, C. A survey of nonparametric tests for the statistical analysis of evolutionary computational experiments. Int. J. Inf. Theor. Appl. 17, pp.49–61 (2010).
21. Toirov, Shukhrat, and Ulugbek Narmuradov. "Processes of applying of quantum genetic algorithm in function optimization." *AIP Conference Proceedings*. Vol. 2365. No. 1. AIP Publishing, 2021.
22. Toirov, Sh A., et al. "Optimization with Quantum Algorithm that is Based on Grover's Method." *International Scientific and Practical Conference on Information Technologies and Intelligent Decision Making Systems*. Cham: Springer Nature Switzerland, 2022.
23. Toirov, Shukhrat. "DESIGN OF GROVER'S QUANTUM SEARCH ALGORITHM FOR 2-KBIT STATES." *Universum: технические науки* 12-7 (117) (2023): 8-11.
24. Sh. A. Toirov, U. X. Mingboyev, A. A. Parmonov, R. B. Kudratov "Designing Grover's quantum searching algorithm for 2-qubit and 3-qubit states of quantum systems" *III International Scientific and Practical Conference "Technologies, Materials Science and Engineering", AIP Conf. Proc. 3243, 010001 (2024) https://doi.org/10.1063/12.0034304*

Ingliz tili muharriri: *Norbekov Shohzod Mamarasul o'g'li*
Sahifalovchi va dizayner: *Zoirov Sardor Ziyodin o‘g‘li*

2026. № 2

Mazkur jurnalda maqolalar chop etish uchun quyidagi havolalarga maqola, reklama, hikoya va boshqa ijodiy materiallar yuborishingiz mumkin.
Materiallar va reklamalar pulli asosda chop etiladi.
El. pochta: journals@timeedu.uz
Tel.: +998 95 651 90 00

“Management and Economics Scientific Research Journal” jurnali 19.09.2024-yildan O‘zbekiston Respublikasi Prezidenti Administratsiyasi huzuridagi Axborot va ommaviy kommunikatsiyalar agentligi tomonidan 404368-son reyestr raqami tartibi bo‘yicha ro‘yxatdan o‘tkazilgan. Litsenziya raqami: C-5669639
PNFL: 308906510

Manzilimiz: *Toshkent shahar Yakkasaroy tumani Shota Rustaveli ko'chasi, 114*