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A SCIENTIFIC APPROACH TO UTILIZING ARTIFICIAL INTELLIGENCE FOR THE DIAGNOSIS AND PREDICTION OF EARLY AGING

Abstract. *Premature ageing is one of the most pressing problems of modern medicine. It is associated with accelerated wear and tear of tissues and organs, which can lead to the development of chronic diseases and reduced life expectancy. In recent years, artificial intelligence (AI) has started to play a key role in healthcare, providing new tools for diagnosis and prognosis. This article reviews current AI advances in the study of premature aging processes, including the use of machine learning to analyse aging biomarkers, estimate biological age, and predict the risk of age-related diseases.*

Key words*: artificial intelligence, premature ageing, biological age, machine learning, biomarkers.*

Introduction. Premature ageing is a complex biological phenomenon characterised by accelerated wear and tear of tissues and organs compared to the chronological age of an individual. This process can be caused by genetic, environmental and lifestyle factors. Premature aging is often accompanied by the appearance of age-related diseases such as cardiovascular diseases, diabetes, osteoporosis and others [1].

With the development of artificial intelligence (AI) and machine learning (ML) in medicine, it is now possible to detect signs of premature aging more accurately and earlier. These technologies can analyse large amounts of data, extracting important biomarkers and patterns that may not be accessible by traditional analysis methods. In this article, we discuss the role of AI in diagnosing and predicting premature aging, as well as its potential to improve health and longevity.

Premature aging is associated with various biological and external factors, including oxidative stress, DNA damage, inflammation and epigenetic changes [2]. In recent years, biomarkers such as telomere length, epigenetic clock, oxidative stress levels and immunological parameters have been actively used as indicators of biological age.

With the development of artificial intelligence (AI) and machine learning (ML) in medicine, it is now possible to detect signs of premature aging more accurately and earlier than ever before. These technologies can analyze vast amounts of biological, genetic, and clinical data, extracting important biomarkers and identifying patterns that might remain undetected through traditional analysis methods. In this review, we discuss the evolving role of AI in diagnosing and predicting premature aging, focusing on its potential to enhance our understanding of the aging process and improve interventions aimed at promoting health and longevity.

AI and ML offer new ways to analyse these biomarkers in order to diagnose and assess the risk of developing age-related diseases. For example, epigenetic changes such as DNA methylation can be used to calculate biological age. This is the so-called ‘epigenetic clock’, which can accurately determine the extent to which an organism is ageing [3].

Results and methods

1. Analysing biomarkers of aging using AI

AI enables comprehensive analyses of aging biomarkers such as telomere length and DNA methylation levels, which helps to estimate the biological age of an individual more accurately than traditional methods. Machine learning can help identify hidden patterns in DNA methylation data and also predict the rate at which an organism ages based on various biomarkers [4].

For example, deep learning algorithms can analyse epigenetic data to estimate biological age from DNA samples. These algorithms are trained on thousands of samples, allowing them to predict biological age with high accuracy. Applying AI to analyse epigenetic data is becoming an increasingly popular approach in ageing research.

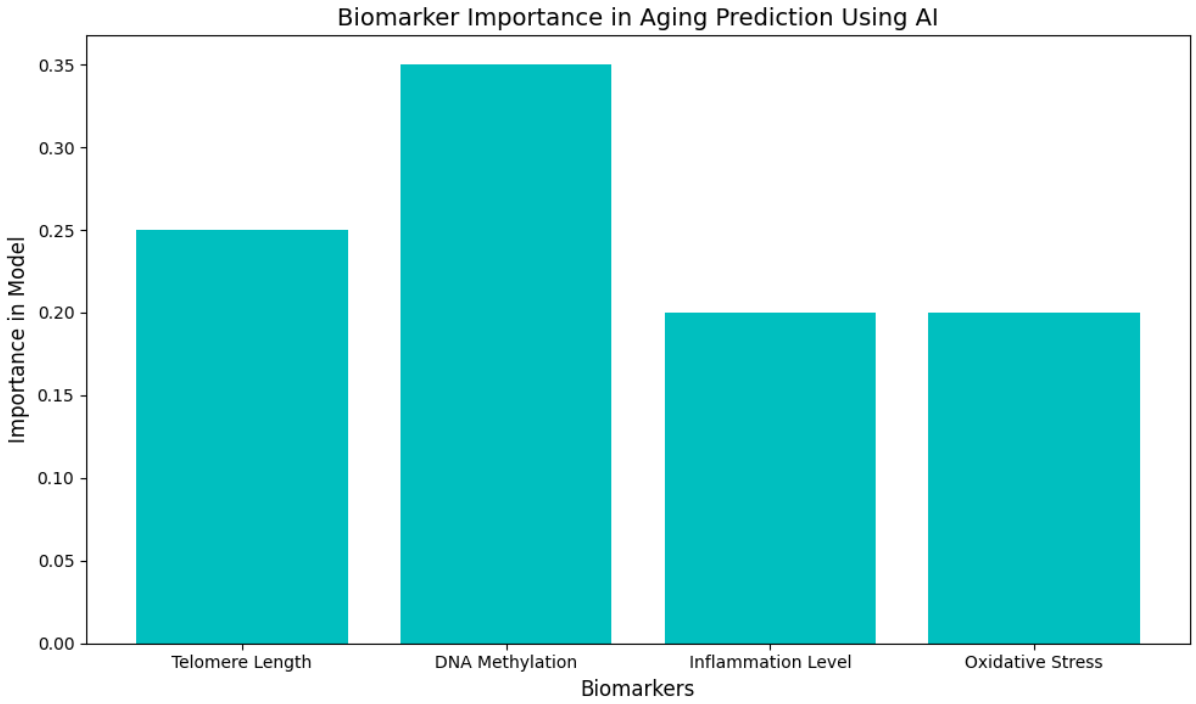

Figure 1. Importance of biomarkers

2. Prediction of age-related diseases

AI is also being actively used to predict age-related diseases associated with premature aging. Machine learning models can analyse patients' medical data, including genetic information, biomarkers and lifestyle, to assess the risk of developing diseases such as Alzheimer's disease, cardiovascular disease and osteoporosis [1].

To illustrate the effectiveness of AI in predicting these diseases, Table 1 summarizes the predicted risks for various age-related conditions and the corresponding accuracy of AI models based on biomarker analysis:

Table 1: Predicting Risk of Age-Related Diseases Using AI

Disease	Biomarker	Predicted Risk (%)	Model Accuracy (%)
Cardiovascular Diseases	Inflammatory Markers, Lipid Profiles	80	92
Type 2 Diabetes	Blood Glucose Level, BMI	60	89
Osteoporosis	Bone Density, Metabolic Markers	50	85
Alzheimer's Disease	Neuroimaging, Neurodegeneration Biomarkers	70	91
Cancer (general risk)	Telomere Shortening, Oxidative Stress	65	87
Premature Aging	Telomere Length, DNA Methylation	75	90

The high accuracy of these AI-driven predictions demonstrates the potential of integrating AI into personalized healthcare strategies for age-related diseases.

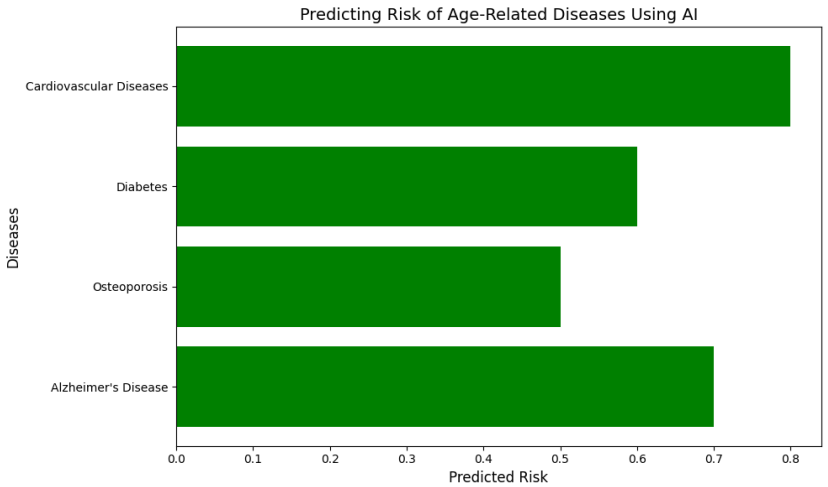

Figure 2. Prediction diseases

One promising approach is to create multimodal models that combine data of different types (e.g., genetic, clinical, and lifestyle) for more accurate prediction. Such

models can reveal relationships between biomarkers of ageing and specific diseases, which facilitates early detection and prevention of these conditions.

3. Estimation of biological age using AI

Traditional age estimation is based on chronological age, but biological age can vary significantly. AI can be used to estimate biological age based on complex analyses of data such as clinical test results, blood biomarkers, genetic data and even images (e.g. skin or internal organs).

The application of deep learning to image analysis (e.g. MRI or ultrasound) allows the assessment of the degree of aging of tissues and organs. These methods are used to diagnose signs of ageing such as loss of skin elasticity, changes in bone density or increased fatty deposits in the area of internal organs [5].

Show how AI models (e.g., epigenetic clocks) can estimate human biological age from DNA methylation data.

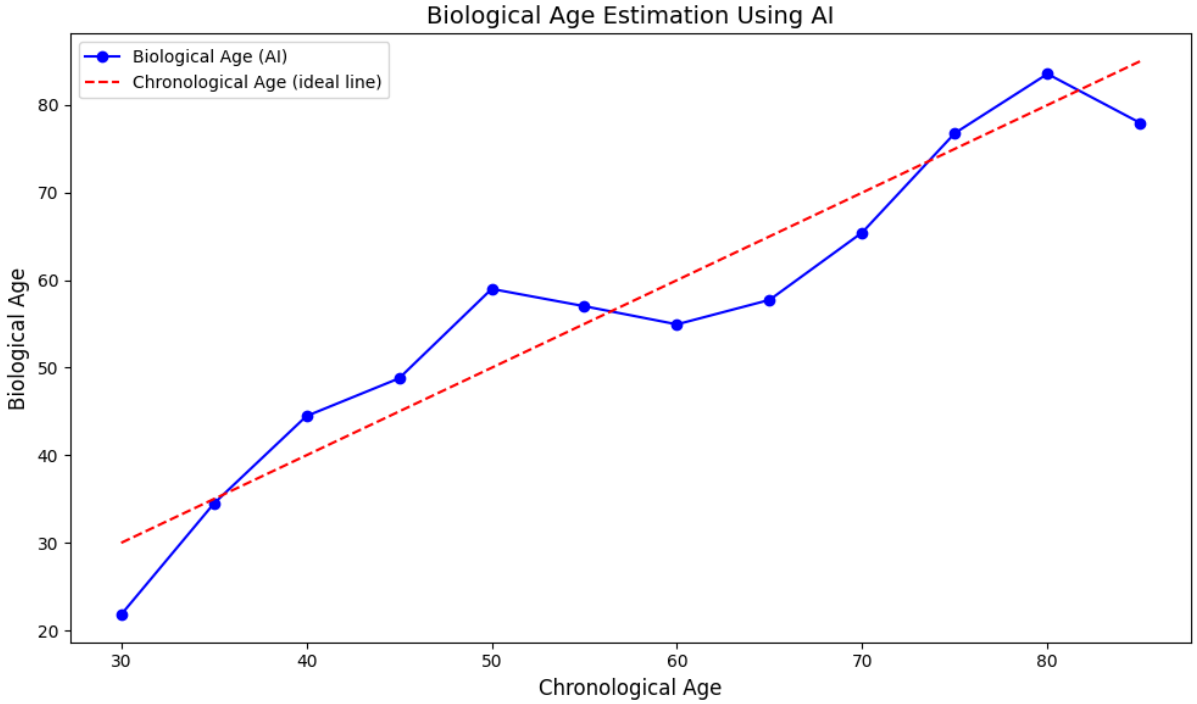

Figure 3. Estimation of biological age

Benefits and limitations of using AI in the study of premature aging

Advantages:

1. High accuracy: Machine learning algorithms can identify hidden patterns in large amounts of data and provide more accurate predictions than traditional methods.

2. Process Automation: Using AI to analyse data automates the diagnostic and monitoring process, which reduces human error and saves resources.

3. Personalised predictions: AI can analyse patient-specific data and provide personalised recommendations based on individual body characteristics.

Limitations:

1. Data availability: Large amounts of high-quality data are required to create quality AI models, which may limit its application.

2. Transparency of algorithms: Many AI algorithms, especially deep learning, are ‘black box’, making it difficult to interpret results and limiting their clinical application. Need for regular updates: AI technologies and medical data are rapidly evolving, requiring models to be constantly updated to maintain their accuracy and relevance.

Future prospects for AI applications

AI has great potential to further develop methods for diagnosing and predicting premature aging. The development of hybrid models that can combine data from different sources such as genomics, epigenetics, and clinical data will help create more accurate and personalised solutions for monitoring ageing [6].

In addition, with advances in data processing technologies and the increasing availability of medical data, we can expect to see more advanced methods for predicting and treating age-related diseases. AI will help create new approaches to prevent premature ageing, which in turn may lead to longer life expectancy and improved quality of life.

Conclusion. The application of artificial intelligence in diagnosing and predicting premature ageing opens new horizons for medicine. AI technologies can help in more accurate estimation of biological age, identifying hidden biomarkers of aging and predicting age-related diseases. Despite existing limitations, such as the need for high-quality data and transparency of algorithms, AI is already showing significant advances in this field. In the future, we can expect AI to become an integral part of healthcare systems aimed at combating premature aging.

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ЕРТЕ ҚАРТАЮДЫ ДИАГНОСТИКАЛАУ ЖӘНЕ БОЛЖАУ ҮШІН ЖАСАНДЫ ИНТЕЛЛЕКТТІ ҚОЛДАНУДЫҢ ҒЫЛЫМИ ТӘСІЛІ

Аңдатпа. *Ерте қартаю-қазіргі медицинадағы ең өзекті мәселелердің бірі. Бұл созылмалы аурулардың дамуына және өмір сүру ұзақтығының қысқаруына әкелуі мүмкін тіндер мен мүшелердің тез тозуымен байланысты. Соңғы жылдары жасанды интеллект (ЖИ) диагностика мен болжаудың жаңа құралдарын ұсына отырып, денсаулық сақтауда шешуші рөл атқара бастады. Бұл мақалада ерте қартаю процестерін зерттеудегі жасанды интеллекттің заманауи жетістіктері, соның ішінде қартаю биомаркерлерін талдау, биологиялық жасты бағалау және жасқа байланысты аурулардың қаупін болжау үшін машиналық оқытуды пайдалану қарастырылады.*

Түйін сөздер: *жасанды интеллект, ерте қартаю, биологиялық жас, машиналық оқыту, биомаркерлер.*

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НАУЧНЫЙ ПОДХОД К ИСПОЛЬЗОВАНИЮ ИСКУССТВЕННОГО ИНТЕЛЛЕКТА ДЛЯ ДИАГНОСТИКИ И ПРОГНОЗИРОВАНИЯ РАННЕГО СТАРЕНИЯ

Аннотация. *Преждевременное старение - одна из самых актуальных проблем современной медицины. Оно связано с ускоренным износом тканей и органов, что может привести к развитию хронических заболеваний и сокращению продолжительности жизни. В последние годы искусственный интеллект (ИИ) начал играть ключевую роль в здравоохранении, предоставляя новые инструменты для диагностики и прогнозирования. В этой статье рассматриваются современные достижения искусственного интеллекта в изучении процессов преждевременного старения, включая использование машинного обучения для анализа биомаркеров старения, оценки биологического возраста и прогнозирования риска возрастных заболеваний. Ключевые слова: искусственный интеллект, преждевременное старение, биологический возраст, машинное обучение, биомаркеры.*

Ключевые слова: *искусственный интеллект, преждевременное старение, биологический возраст, машинное обучение, биомаркеры.*

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