QuantumBasel

Center of Competence
for Quantum Computing and AI

AI | Quantum | DNA Sequencing

Advancing AI for Detecting Circulating Rare Cells (CRCs)

2025 | Use Case | Faster and Accessible Molecular Testing for Lung Cancer Patients

Moonlight AI is pioneering AI-driven healthcare solutions, specifically targeting the lengthy and expensive molecular testing process for cancer patients. Moonlight AI's approach, which uses AI to analyze blood smear slides, dramatically reduces turnaround time. However, this approach requires a combination of unprecedented sensitivity and scalability. To address this, Moonlight AI is exploring quantum algorithms to improve the efficiency of its AI, with the goal of providing faster, more accessible cancer diagnostics. This project is a collaboration between QuantumBasel and Moonlight AI.

THE CHALLENGE

Hematologic cancers affect approximately 1.7 million people worldwide, and with advancements in precision medicine, genomic information from molecular testing such as Next-Generation Sequencing (NGS) is crucial for matching patients to targeted therapies. However, access to this vital information is limited by high costs and the need for proximity to specialized instruments. This is especially problematic for cancer patients, who require timely molecular testing to guide treatment decisions and montor disease progression. Currently, detecting blood mutations is an expensive, time-consuming process (over 10 days) that requires specialized equipment. As a result, even though 70% of patients with hematologic malignancies would benefit from NGS [1], fewer than 20% of patients receive this essential testing.

Moonlight AI uses advanced AI techniques to give more patients access to molecular testing results by analyzing images of a patient's blood smear slide. This avoids the problem of needing specialized equipment and can result in a turnaround time of just under an hour.

1.7 mio
people worldwide affected

>10
days process to detect mutations

<20%
of blood patients do not receive essential testing

[1] Source: https://ascopubs.org/doi/10.1200/JCO.2017.35.15_suppl.e23133

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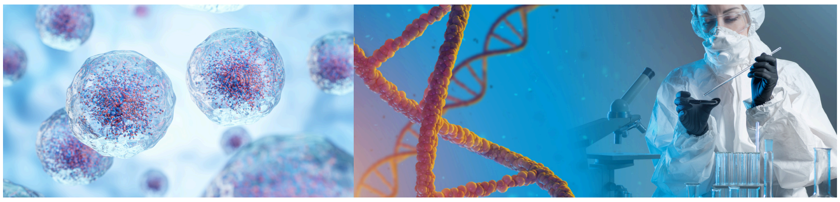
PROJECT GOAL

Detecting anomalies in the blood can be a needle in a haystack problem. This requires an AI solution with unprecedented sensitivity and scalability in order to be fully applicable in practice. This proof of concept project aimed at understanding how the use of quantum algorithms can help remove some of these bottlenecks by increasing the efficiency of their AI solution.



SOLUTION APPROACH

We developed two novel machine learning solutions to overcome the current bottleneck in feature aggregation—a critical step in data analysis for cancer diagnostics. Using a classical AI approach, the team significantly improved the accuracy of circulating rare cell (CRC) detection while also reducing computational costs. Building on this, the solution was enhanced with a quantum algorithm, currently in the prototype stage, which has the potential to deliver even greater accuracy and further reductions in computational demand. Both approaches are patented, giving Moonlight AI immediate value through a deployable classical solution, while also positioning the company at the forefront of quantum adoption for CRC detection as the technology continues to evolve.

„Our collaboration with QuantumBasel has delivered results quickly and consistently, thanks to their agile approach and dedication to understanding the value drivers in our business. They built trust by treating us as thought partners and educating us when needed. The team's expertise, professionalism, and practical mindset truly set QuantumBasel apart from others in the space."

Nicole Romano, Co-Founder and CTO, Moonlight AI

10-15%
accuracy boost from data improvement

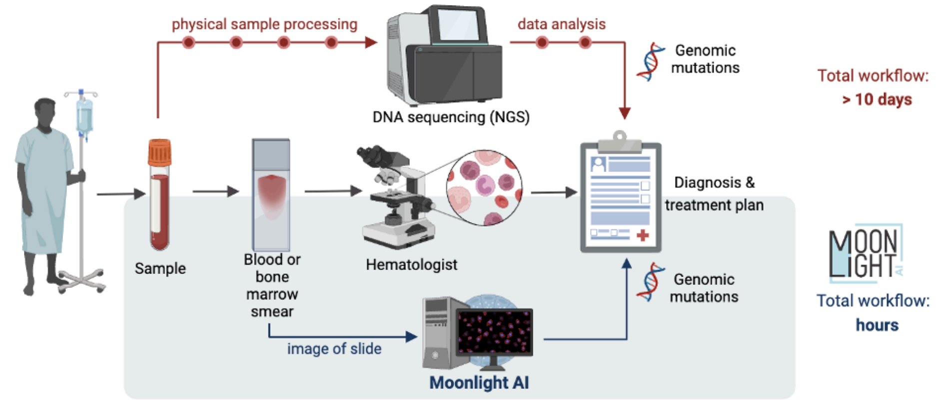
>10%
increase in AUC from model improvements

5x
decrease in training complexity

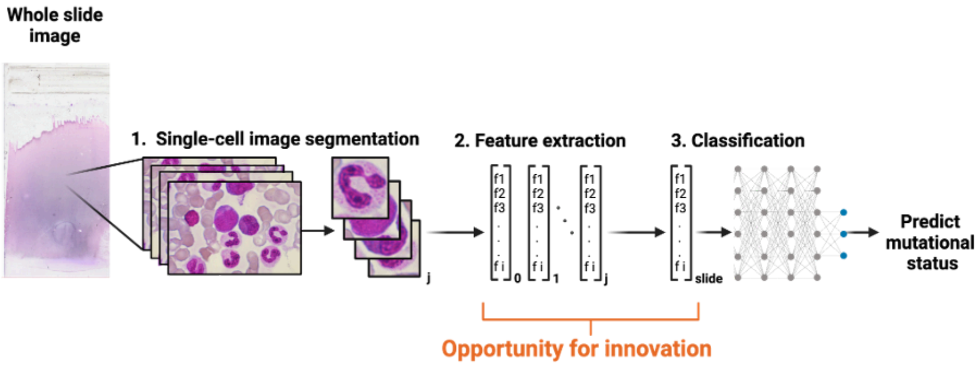
NEXT STEPS

Having done a proof of concept of this technique, the first deliverable was to file a patent to ensure that the IP is protected. Then the immediate next step is to focus on the quantum algorithm to understand how to take it from proof-of-concept to production and the timeline required to do so.

DETAILED INFORMATION



Detection and classification of cell morphologies are carried out by sampling the patient's blood and processing the sample through a DNA sequencer before analyzing the results. A much more efficent way would be to use Multiple Instance Learning (MIL) AI tools. A key bottleneck in this methodology is the computational complexity and high number of trainable parameters in deep learning-based attention mechanisms used in multiple instance learning (MIL), which can hinder training efficiency.



To overcome this, the paper proposes a novel attention-based extreme learning machine (extreme MIL) approach that significantly reduces the number of trained parameters while achieving comparable performance to deep MIL models in rare cell detection. Deep MIL models train all parameters through backpropagation, while extreme MIL freezes most parameters in the attention mechanism, only training the final classification layer. Our key improvements over the previous state-of-the-art include

- Higher-dimensional feature space in the aggregation step of the attention-based deep MIL model which led to a considerable improvement in performance (>10% in AUC) and robustness
- Domain-specialized pre-processing which yields substantial performance improvements across all models
- Extreme MIL achieved comparable performance to deep MIL while reducing the number of trained parameters by a factor of 5

The paper can found on arXiv [2].

For more details don't hesitate to contact us!

[2] https://arxiv.org/pdf/2503.10510