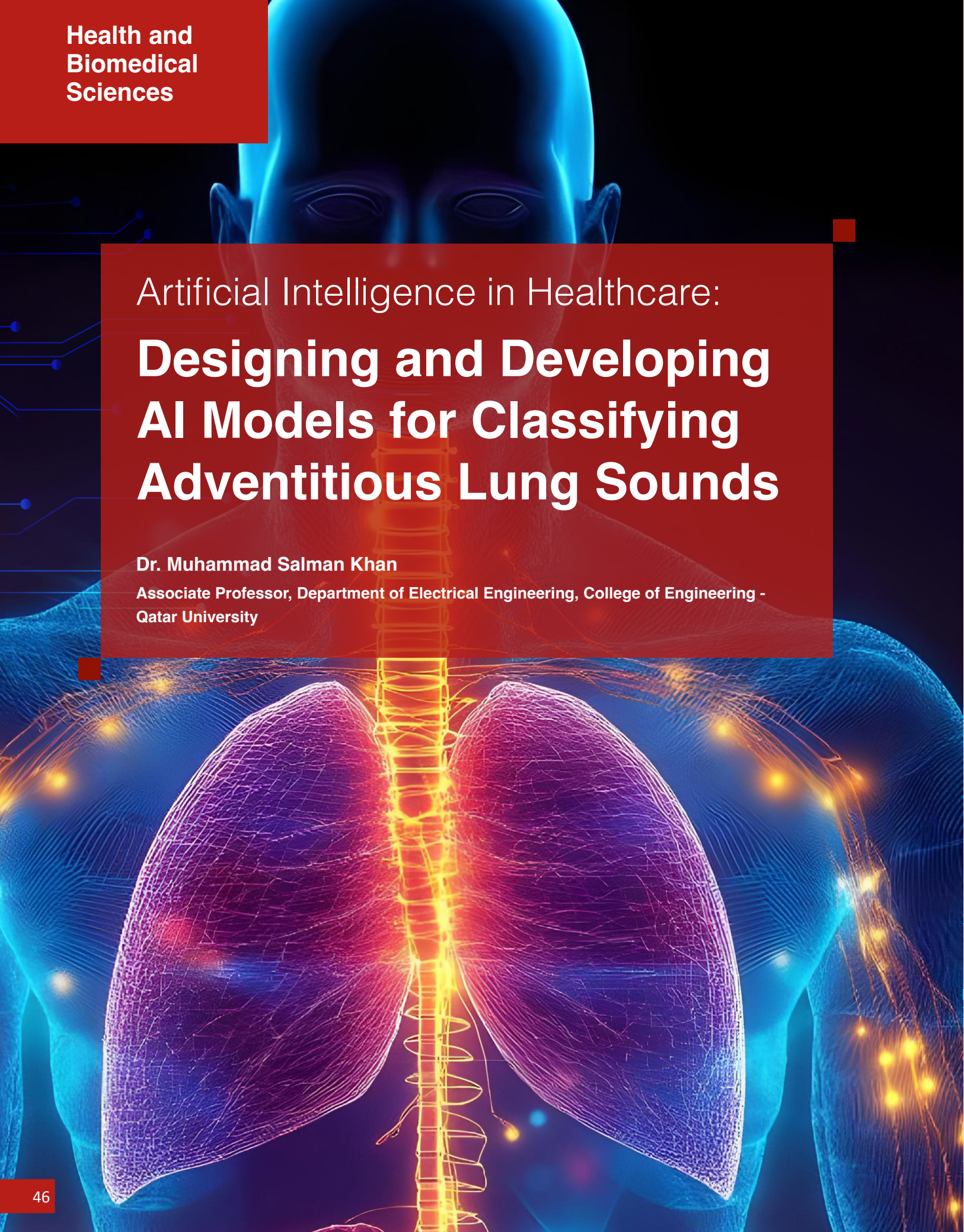

Artificial Intelligence in Healthcare:

Designing and Developing AI Models for Classifying Adventitious Lung Sounds

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Healthcare is one of the most vital pillars of human society, playing a critical role in ensuring physical and mental well-being. The prevention, diagnosis, treatment, and recovery from illness, along with the search for cures, are the fundamentals to maintaining healthy populations. However, diagnosing and detecting abnormal conditions can be complex, often carrying the risk of misdiagnosis and human error. In recent years, medical practice has been revolutionized through the integration of various fields such as computational mathematics, statistics, computer science, bioinformatics, and, most notably, artificial intelligence (AI). AI has the potential to analyze and interpret vast amounts of medical data through sophisticated algorithms, enabling more accurate diagnoses, personalized treatment plans, and overall improvements in healthcare outcomes. By minimizing errors and enhancing decision-making processes, AI is transforming the way healthcare systems operate, ushering in a new era of precision and efficiency in medical practice.

Training research, development, and innovation talent in Qatar is crucial for advancing the nation's healthcare sector and addressing national and international health challenges. By equipping researchers and professionals with cutting-edge skills such as signal processing, machine learning, and deep learning, Qatar can foster the development of sophisticated tools and technologies for disease detection from biomedical and health data. These skills are essential for improving diagnostic accuracy, developing personalized treatments, and enhancing healthcare efficiency. Additionally, nurturing talent in these areas will enable Qatar to lead in the global arena of medical research and innovation, contributing to the country's vision of becoming a knowledge-based state. This investment in training not only strengthens the local workforce but also supports the broader goal of advancing healthcare outcomes for both Qatar and the international community.

The Department of Electrical Engineering, College of Engineering, Qatar University, strives to train students with fundamental skills that are essential for driving healthcare innovation in Qatar and beyond. This is achieved by providing comprehensive education in fields such as electronics, signal processing, machine learning, and deep learning, preparing students to tackle complex challenges in disease detection and healthcare analytics. The senior design project (SDP) is an important part of the engineering training. The primary goal of the SDP project is to develop students' technical, research, and communication skills through hands-on design, development, teamwork, and presentations. It also emphasizes professional practice and non-technical factors, such as safety, environmental, and social impacts, while encouraging adherence to ethical standards and relevant regulations.

Recently, engineering students undertook a graduation project focused on designing and developing AI models for classifying adventitious lung sounds. The project team comprised students Hamad Alyafei, Mohammed Nour, and Abdulla Al-Obaidan, under

Dr. Muhammad Salman Khan with his students, Hamad Alyafei (left) Mohammed Nour and Abdulla Al-Obaidan (right).

Student training on a manikin with pre-recorded normal and abnormal respiratory sounds.

the supervision of Dr. Muhammad Salman Khan, Associate Professor in the Department of Electrical Engineering at Qatar University.

Lung sounds, which are also called respiratory or breath sounds, are the noises created when air moves through the respiratory system and can be heard through a stethoscope—a process known as auscultation. Auscultation of the lungs is a fundamental diagnostic practice in medicine, used primarily to assess respiratory health and identify abnormalities in the lungs and airways. When performing auscultation, a healthcare provider listens for the quality, intensity, and pattern of these sounds. Normal lung sounds include vesicular breath sounds heard over most of the lung fields, while abnormal sounds, such as wheezes, crackles, or stridor, may indicate respiratory conditions like asthma, pneumonia, or obstructive pulmonary disease.

The students began by conducting a thorough literature review to fully understand the problem, explore the current state of the art, and define the objectives for their SDP project. They were guided on how to access and review research publications in the field, as well as how to conduct market research on existing commercial solutions. The team utilized a publicly available dataset, widely recognized by the research community, which contained both normal and abnormal lung sounds. After downloading the dataset, the students performed preprocessing tasks, including resampling, normalization, and filtering. They were trained in the signal processing techniques required for lung sound analysis and then focused on learning various machine learning and deep learning algorithms. This process involved dataset preparation, feature extraction, and the training, validation, and testing of different classification models. The students engaged with both the theoretical aspects and the practical, and the hands-on implementation of AI models for lung sound classification.

The SDP group also collaborated with students from the College of Medicine (CMED) at Qatar University (QU), co-mentored by Dr. Maha Desouki, Section Head of Pre-Clinical Education. This partnership was established under the QRDI UREP grant (UREP30-168-2-052) for the project titled “Learning, Identifying, Recording, Analyzing, and Computer-Aided Detection of Abnormal Respiratory Sounds.” Through this initiative, the engineering students had the opportunity to visit the clinical skills lab at CMED, where they received hands-on training using manikins with pre-recorded normal and abnormal lung sounds. Regular meetings were held as part of the project, where medical and engineering students exchanged knowledge and shared experiences, fostering a collaborative environment for multidisciplinary research, development, and innovation.

In conclusion, this interdisciplinary collaboration between engineering and medical students at Qatar University has played a pivotal role in nurturing the next generation of research, development, and innovation talents in healthcare. The project not only enhanced the students’ technical expertise by integrating artificial intelligence with clinical practice but also fostered a multidisciplinary approach essential for addressing complex challenges in the healthcare sector. This collaboration between students and researchers marks a significant step toward improving healthcare outcomes and advancing medical technology.