

Received January 11, 2021, accepted January 24, 2021, date of publication February 16, 2021, date of current version March 15, 2021.

Digital Object Identifier 10.1109/ACCESS.2021.3059858

A Review on the Role of Machine Learning in Enabling IoT Based Healthcare Applications

HEMANTHA KRISHNA BHARADWAJ¹, AAYUSH AGARWAL¹,
VINAY CHAMOLA^{1,2}, (Senior Member, IEEE), NAGA RAJIV LAKKANIGA^{3,7},
VIKAS HASSIJA⁴, MOHSEN GUIZANI⁵, (Fellow, IEEE),
AND BIPLAB SIKDAR⁶, (Senior Member, IEEE)

¹Department of Electrical and Electronics Engineering, Birla Institute of Technology and Science (BITS), Pilani 333031, India

²APPCAIR, Birla Institute of Technology and Science (BITS), Pilani 333031, India

³Department of Integrative Structural and Computational Biology, The Scripps Research Institute, La Jolla, CA 92037, USA

⁴Department of CSE and IT, Jaypee Institute of Information Technology, Noida 201309, India

⁵Department of Computer Science and Engineering, Qatar University, Doha 2713, Qatar

⁶Department of Electrical and Computer Engineering, National University of Singapore, Singapore 117583

⁷SmartBio Labs, Chennai 600078, India

Corresponding author: Biplab Sikdar (bsikdar@nus.edu.sg)

The work of Biplab Sikdar was supported in part by the Singapore Ministry of Education Academic Research Fund Tier 1 under Grant R-263-000-D63-114. The work of Vinay Chamola was supported by the BITS Additional Competitive Research Grant funding under Grant PLN/AD/2018-19/6.

ABSTRACT The Internet of Things (IoT) is playing a vital role in the rapid automation of the healthcare sector. The branch of IoT dedicated towards medical science is at times termed as Healthcare Internet of Things (H-IoT). The key elements of all H-IoT applications are data gathering and processing. Due to the large amount of data involved in healthcare, and the enormous value that accurate predictions hold, the integration of machine learning (ML) algorithms into H-IoT is imperative. This paper aims to serve both as a compilation as well as a review of the various state of the art applications of ML algorithms currently being integrated with H-IoT. Some of the most widely used ML algorithms have been briefly introduced and their use in various H-IoT applications has been analyzed in terms of their advantages, scope, and possible improvements. Applications have been divided into the domains of diagnosis, prognosis and spread control, assistive systems, monitoring, and logistics. In healthcare, practical use of a model requires it to be highly accurate and to have ample measures against security attacks. The applications of ML algorithms in H-IoT discussed in this paper have shown experimental evidence of accuracy and practical usability. The constraints and drawbacks of each of these applications have also been described.

INDEX TERMS Healthcare, Internet of Things, machine learning, diagnosis, monitoring, cardiovascular, neurological.

I. INTRODUCTION

The Internet of Things (IoT) has been the subject of great enthusiasm in the healthcare technology community over the last few years. The healthcare domain is of great practical importance and IoT opens up a wide spectrum of opportunities to make it better. Numerous contemporary medical devices and sensors can connect over various networks, which provides access to important information about patients' conditions. This information can then be used for multiple purposes such as monitoring patients remotely, predicting illness and recovery through the greater insight into symptoms, and

generally improving the diagnosis and treatment process via increased automation and portability.

Due to the vast multitude of data generated in real-time by these devices and their complex nature, analysis using ML algorithms has proven to be of vital importance to H-IoT. These algorithms allow us to extract valuable information from the acquired data and draw useful inferences. Though ML models can provide great levels of accuracy when trained in the right environment, this is generally easier said than done. Various contemporary research efforts are aimed at finding out new areas of applications of ML algorithms to H-IoT systems, evaluating their suitability for these systems, and increasing the accuracy achieved by prediction and analysis models.

The associate editor coordinating the review of this manuscript and approving it for publication was Diana Patricia Tobon¹.