Broadening the horizons: An Intelligent AI-based Diagnostic System for Medical Triage and Treatment Recommendations

A Proposal by

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0.1 Introduction

Healthcare systems globally are strained by mounting patient loads, limited accessibility to specialists, and often prohibitively long wait times for diagnosis and treatment. Particularly in low-resource settings, these challenges translate into significant delays in diagnosis, misdiagnosis, and at times, preventable mortality [WHO, 2018b, Hirano and Yamaguchi, 2019]. Despite advances in diagnostic protocols, traditional healthcare systems continue to falter in effectively managing large-scale demands and providing timely, accessible, and accurate diagnoses [Lee and Yoon, 2018]. In recent years, artificial intelligence (AI) has emerged as a promising solution to these systemic issues, showing potential to revolutionize diagnostics, enhance healthcare delivery, and improve patient outcomes across various medical contexts [Esteva et al., 2017, Rajpurkar et al., 2018].

Machine learning (ML) models, particularly large language models (LLMs), have made significant strides in analyzing patient-reported symptoms. These models, designed to process vast amounts of natural language data, are adept at identifying patterns that align with diagnostic criteria [Radford et al., 2019]. In parallel, computer vision (CV) advancements have facilitated detailed analysis of medical imaging, supporting faster and often more accurate interpretations than traditional manual methods [Kermany et al., 2018, McKinney et al., 2020]. Research in AI-driven diagnostics has yielded promising results in both fields, demonstrating capabilities in symptom analysis and image interpretation that rival, and in some cases exceed, those of human specialists [Topol, 2019].

This study proposes a solution to bridge diagnostic gaps in Zimbabwe, where healthcare resources are stretched thin, and patient access to diagnostic specialists is limited. Zimbabwean healthcare facilities, especially in rural and underserved regions, struggle with staff shortages and delayed specialist diagnoses, leaving patients waiting extended periods for critical care [World Health Organization, 2023]. Implementing an AI-based diagnostic system that combines text-based symptom analysis and scan-image interpretation holds immense potential for transforming healthcare accessibility in these settings. By enabling timely, accurate, and automated diagnostics, such a system could alleviate diagnostic delays, enhance treatment efficacy, and save lives. With Zimbabwe's unique healthcare challenges in mind, this study aims to develop an integrated AI diagnostic platform capable of supporting and augmenting local healthcare delivery.

0.2 Background of the Study

The global health landscape is at a critical juncture as we strive to achieve the Sustainable Development Goals (SDGs), particularly the 2030 agenda of leaving no one behind. Healthcare systems worldwide, particularly in low-income countries, have been historically inadequate in ensuring equitable access to essential health services. This inequity is starkly evident in Africa, where healthcare infrastructures often lack the resources to meet the growing demands of expanding populations [WHO, 2018b, Molla, 2019]. The failure of previous healthcare systems to incorporate all individuals, especially marginalized groups, has exacerbated disparities in health outcomes [Kendall, 2020, Oxfam, 2021].

Access to healthcare facilities remains a pressing challenge, with a notable shortage of medical specialists in many regions. According to the World Health Organization (2020), Africa faces a severe shortage of healthcare professionals, with only 2.3 doctors, nurses, and midwives per 1,000 people—well below the global average of 9.3. This lack of specialists has resulted in overwhelming patient loads, leading to increased wait times and insufficient diagnostic capabilities. Recent analyses have highlighted that the healthcare workforce is not only inadequate but also unevenly distributed, leaving rural and underserved areas particularly vulnerable [Buchan, 2020, Nkengafac, 2021].

In Zimbabwe, the situation is no different. The Zimbabwe Health Report (2022) emphasizes the challenges faced by the healthcare system, including high incidences of preventable diseases, inadequate access to diagnostic services, and the persistent effects of economic instability on healthcare delivery. The country's healthcare facilities struggle to provide timely and accurate diagnoses, resulting in delayed treatment and poorer health outcomes for the population. The ongoing COVID-19 pandemic has further exacerbated these challenges, revealing critical gaps in the healthcare infrastructure and the urgent need for innovative solutions [WHO, 2018a].

This study aims to address these gaps by proposing an integrated AI-based diagnostic platform that leverages machine learning and computer vision technologies. By analyzing patient-reported symptoms alongside medical imaging data, this system aspires to enhance diagnostic accuracy and accessibility in Zimbabwe's healthcare landscape. The anticipated benefits include timely identification of health conditions, reduced burdens on healthcare professionals, and improved patient outcomes. By creating a solution that is both locally relevant and technologically advanced, we hope to bridge the existing healthcare gaps and contribute to the global effort of ensuring that no one is left behind in achieving health equity.

0.3 Problem Statement

In Zimbabwe, the healthcare system faces a dire challenge that impacts millions of lives: inadequate access to timely and accurate medical diagnostics. This situation is particularly alarming in rural and underserved areas where healthcare facilities are overwhelmed and understaffed, leaving patients vulnerable to undiagnosed or misdiagnosed conditions. Reports indicate that over 80% of Zimbabweans rely on the public health system, which is characterized by long wait times, limited specialist availability, and a lack of essential diagnostic tools [World Health Organization, 2023]. As a result, patients often endure prolonged periods of uncertainty, suffering from conditions that require early detection and intervention, ultimately leading to preventable complications and even mortality.

The existing healthcare infrastructure, hampered by economic constraints and a shortage of qualified professionals, struggles to meet the increasing demands of a growing population [WHO, 2018b, Nkengafac, 2021]. Patients frequently report feelings of despair and helplessness as they navigate a system that falls short of their needs. For instance, many individuals in rural communities travel long distances to access care, only to encounter delays in diagnosis that can exacerbate their conditions [Molla, 2019].

This study seeks to address these pressing issues by developing an integrated AI-based diagnostic platform that combines advanced machine learning techniques with computer vision capabilities. By utilizing patient-reported symptoms alongside medical imaging data, this system aims to provide prompt, accurate diagnoses that are crucial for effective treatment. Ultimately, this research aspires to not only enhance the efficiency of healthcare delivery in Zimbabwe but also restore hope and improve health outcomes for individuals who have long suffered in silence due to systemic inadequacies. This vision aligns with the global commitment to achieve universal health coverage and ensure that no one is left behind in the pursuit of health equity.

0.4 Objectives

The primary aim of this study is to develop an AI-based diagnostic system to improve patient diagnostic accuracy and efficiency. Specific objectives include:

1. To design an LLM-based model capable of diagnosing patient-reported symptoms with high accuracy.

2. To integrate computer vision algorithms for interpreting scan images to enhance diagnostic precision.

3. To evaluate the system's diagnostic performance compared to conventional diagnostic timelines in Zimbabwe.

0.5 Significance of the Study

The proposed AI-based diagnostic system stands to benefit various stakeholders within Zimbabwe's healthcare landscape, enhancing efficiency, accuracy, and overall patient care:

Healthcare Providers:** Physicians will gain access to advanced diagnostic support tools that can significantly reduce the time spent on preliminary diagnoses. By leveraging large language models (LLMs) and computer vision technologies, doctors can quickly analyze patient-reported symptoms and relevant medical images, leading to more informed clinical decisions. This efficiency not only alleviates the workload for healthcare professionals but also fosters a collaborative environment where technology complements human expertise [Wang, 2018, Esteva, 2019].

Patients:* For patients, the most immediate benefit lies in the promise of quicker and more accurate diagnoses. This system aims to transform the patient experience by providing actionable treatment plans based on real-time analysis of symptoms and diagnostic data. Timely interventions can lead to improved health outcomes, reduced anxiety associated with waiting for diagnoses, and overall satisfaction with the healthcare process [Ghassemi, 2018, Rajpurkar, 2019]. Empowered with better insights, patients will be more engaged in their health journey, fostering a partnership with their healthcare providers.

Healthcare Facilities:* Clinics and hospitals will benefit from a reduction in diagnostic backlogs, allowing them to manage patient volumes more effectively. The integration of this AI platform can optimize the allocation of specialist resources, ensuring that high-demand areas receive the attention they need while alleviating strain on overburdened facilities. This optimization not only enhances operational efficiency but also contributes to the sustainability of healthcare services in Zimbabwe [Chibanda, 2019].

Government and Policymakers:* The findings and evidence generated from this study could serve as a foundation for policy initiatives aimed at incorporating AI technologies into the healthcare system. By demonstrating the potential for improved public health outcomes through technology integration, this research could influence decision-makers to allocate resources towards innovative solutions that address systemic healthcare challenges. This alignment with global health initiatives, such as the Sustainable Development Goals (SDGs), underscores the importance of modernizing healthcare delivery to leave no one behind [UN, 2015, WHO, 2021]

This multifaceted approach not only enhances healthcare delivery in Zimbabwe but also positions the country as a forward-thinking leader in the integration of AI technologies within the healthcare sector.

0.6 Requirements

0.6.1 Data Requirements

The successful implementation of the AI-based diagnostic system hinges on the acquisition and utilization of diverse data types. These data requirements are critical to ensure the model's accuracy, reliability, and effectiveness in diagnosing medical conditions.

- **Text Data:**
  - *Patient-Reported Symptoms:* Data collected from patients through surveys, questionnaires, or digital health platforms will provide crucial insights into their health status. This text data should encompass detailed descriptions of symptoms, duration, severity, and any related factors that could aid in diagnosis [Hirsch, 2020, Naylor, 2021]. Natural Language Processing (NLP) techniques will be employed to preprocess and analyze this data, transforming it into structured formats that the model can interpret.
  - *Doctor's Notes:* Clinical notes written by healthcare providers during patient consultations are invaluable sources of information. These notes often contain nuanced observations and differential diagnoses that can enhance the understanding of patient conditions [Rosenbloom, 2011, Wang, 2018]. By aggregating this data, the model can learn from real-world clinical insights, improving its diagnostic capabilities.
- **Image Data:**
  - *Medical Imaging:* High-quality images from various diagnostic scans, including X-rays, Magnetic Resonance Imaging (MRIs), and Computed Tomography (CT) scans, are essential for accurate analysis and interpretation. These images should be annotated with relevant clinical information, such as diagnosis, patient demographics, and imaging techniques used [Kermany et al., 2018,

McKinney et al., 2020]. The incorporation of image data will enable the application of computer vision algorithms, facilitating automated anomaly detection and diagnosis.

– *Standardization of Data Formats:* It is vital to ensure that all imaging data adheres to standardized formats, such as DICOM (Digital Imaging and Communications in Medicine), to maintain consistency and compatibility across different imaging devices and software[Ayub, 2021]. This standardization will support the integration of diverse datasets and enhance the model's performance in clinical settings.

The careful selection and curation of both text and image data will significantly influence the effectiveness of the diagnostic system. By leveraging comprehensive datasets that capture the complexity of patient experiences and clinical observations, the AI platform will be better equipped to provide accurate, timely, and actionable diagnoses.

Bibliography

[Ayub, 2021] Ayub, N. e. a. (2021). Dicom standard: An overview. *IEEE Access*, 9:115382–115397.

[Buchan, 2020] Buchan, J. e. a. (2020). Global health workforce: A global perspective. *Human Resources for Health*, 18(1):1–10.

[Chibanda, 2019] Chibanda, D. e. a. (2019). Integrating mental health into primary care: A global perspective. *The Lancet Psychiatry*, 6(10):835–844.

[Esteva et al., 2017] Esteva, A., Kuprel, B., Novoa, R. A., Ko, J., Swetter, S. M., Blau, H. M., and Thrun, S. (2017). Dermatologist-level classification of skin cancer with deep neural networks. *Nature*, 542(7639):115–118.

[Esteva, 2019] Esteva, A. e. a. (2019). A guide to deep learning in healthcare. *Nature Medicine*, 25(1):24–29.

[Ghassemi, 2018] Ghassemi, M. e. a. (2018). Clinical machine learning in the big data era. *Journal of Medical Internet Research*, 20(2):e88.

[Hirano and Yamaguchi, 2019] Hirano, Y. and Yamaguchi, T. (2019). Challenges of healthcare systems in low-income countries. *International Journal of Health Policy and Management*, 8(3):122–129.

[Hirsch, 2020] Hirsch, A. e. a. (2020). Patient-reported outcomes: A systematic review of their use in trials of mental health interventions. *Journal of Affective Disorders*, 265:351–360.

[Kendall, 2020] Kendall, J. e. a. (2020). Health systems strengthening: The critical role of universal health coverage. *Global Health Action*, 13(1):1707423.

[Kermany et al., 2018] Kermany, D. S., Goldbaum, M., Cai, W., Valentim, C. C., Liang, H., Baxter, S. L., McKeown, A., Yang, G., Wu, X., Yan, F., et al. (2018). Identifying medical conditions from retinal oct images using deep learning. *Cell*, 172(5):1122–1131.e9.

[Lee and Yoon, 2018] Lee, D. and Yoon, J. (2018). Failings of global healthcare: Addressing inefficiencies in healthcare access and diagnosis. *Journal of Global Health Research*, 5(1):30–42.

[McKinney et al., 2020] McKinney, S. M., Sieniek, M., Godbole, V., Godwin, J., Antropova, N., Ashrafian, H., Back, T., Chesus, M., Corrado, G. S., Darzi, A., et al. (2020). International evaluation of an ai system for breast cancer screening. *Nature*, 577(7788):89–94.

[Molla, 2019] Molla, M. e. a. (2019). The healthcare access challenge in zimbabwe: Experiences of patients in rural areas. *International Journal for Equity in Health*, 18(1):1–12.

[Naylor, 2021] Naylor, M. e. a. (2021). The role of patient-reported outcomes in health care: Opportunities and challenges. *Journal of Nursing Administration*, 51:122–128.

[Nkengafac, 2021] Nkengafac, B. e. a. (2021). Barriers to healthcare access in zimbabwe: The role of socio-economic factors. *BMC Health Services Research*, 21(1):1–12.

[Oxfam, 2021] Oxfam (2021). Inequalities in health: A major concern for sustainable development. Accessed: 2024-10-26.

[Radford et al., 2019] Radford, A., Wu, J., Child, R., Luan, D., Amodei, D., and Sutskever, I. (2019). Language models are unsupervised multitask learners. *OpenAI Research*, 1:1–24.

[Rajpurkar et al., 2018] Rajpurkar, P., Irvin, J., Zhu, K., Yang, B., Mehta, H., Duan, T., Ding, D., Bagul, A., Langlotz, C. P., Shpanskaya, K., et al. (2018). Deep learning for chest radiograph diagnosis: A retrospective comparison of the chexnet algorithm to practicing radiologists. *PLOS Medicine*, 15(11):e1002686.

[Rajpurkar, 2019] Rajpurkar, P. e. a. (2019). Chexnet: Radiologist-level pneumonia detection on chest x-rays with deep learning. *arXiv preprint arXiv:1711.05225*.

[Rosenbloom, 2011] Rosenbloom, S. T. e. a. (2011). Clinical decision support: A review of the state of the art. *Journal of the American Medical Informatics Association*, 18(6):736–743.

[Topol, 2019] Topol, E. (2019). *Deep Medicine: How Artificial Intelligence Can Make Healthcare Human Again*. Basic Books.

[UN, 2015] UN (2015). Transforming our world: the 2030 agenda for sustainable development. Accessed: 2024-10-26.

[Wang, 2018] Wang, F. e. a. (2018). Artificial intelligence in healthcare: Past, present, and future. *Health Information Science and Systems*, 6(1):1–10.

[WHO, 2018a] WHO (2018a). The state of health in zimbabwe: A country profile. Accessed: 2024-10-26.

[WHO, 2018b] WHO (2018b). *World Health Statistics 2018: Monitoring Health for the SDGs, Sustainable Development Goals*. World Health Organization, Geneva.

[WHO, 2021] WHO (2021). World health organization: Building back better: A sustainable and resilient health system. Accessed: 2024-10-26.

[World Health Organization, 2023] World Health Organization (2023). Who zimbabwe annual report 2022. Technical report, World Health Organization Regional Office for Africa. Accessed: 2024-10-26.