National Institute of Technology Rourkela

Defence Seminar

Seminar Title	: Attention Learning and Generative Artificial Intelligence Platforms for Advanced Diabetes Management
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Abstract : Diabetes is a chronic condition that requires accurate insulin treatment through multiple daily injections (MDI) and frequent glucose testing. Both internationally and in India, its prevalence is increasing. For effective management of diabetes, artificial pancreas (AP) have been used in recent years to mimic the physiological ability to maintain blood glucose homeostasis, through continuous monitoring and controlled dosing. However, AP technologies' shortcomings including inaccurate insulin dosages brought on by a lack of multimodal data, error in human reporting of meal times, meal amounts, and lack of physical activity input, high device costs, a lack of operational awareness, and loss of connectivity, have prevented their widespread adoption. The major goal of the project is to develop accurate glucose forecasting methods for artificial pancreas and in MDI systems while smoothly integrating physical activity, abiotic variables, including nutrition, and CGM. This thesis explores advanced methodologies for improving diabetes management systems, focusing on glucose forecasting and insulin dose optimization through attention learning and generative AI.

The research commences with the creation of a novel hybrid deep learning model that modifies and integrates traditional time series forecasting with attention learning, the WideDeep-LSTMGRU, which incorporates content-based attention mechanisms to improve the accuracy of glucose prediction. This model exhibits better performance in comparison to baseline methods when tested across both clinical and in-silico datasets. Additionally, a specialized architecture, InsNET, was developed to forecast insulin dosages for closed-loop diabetes management. The significance of personalization in glycemic control was underscored by the significant improvement in prediction accuracy that resulted from the integration of unannounced physical activity data through Bahdanau attention learning.

To address challenges in model interpretability and forecasting accuracy, novel attention learning based architectures were developed by embedding multihead attention learning within neural basis expansion networks and neural hierarchical interpolation networks. The proposed methods improve accuracy and interpretability, progressing towards dependable and user-focused solutions for diabetes management.Furthermore, generative AI was employed to mitigate data loss in continuous glucose monitoring sensor systems. A distinctive GAN-based architecture was created for the creation of synthetic data, encompassing glucose levels, physical activity, and meal information. This data augmentation technique, validated across multiple datasets, enhanced the efficacy of glucose prediction models when actual and synthetic data were combined.

The thesis also presents the backend integration and deployment of the proposed models via a cloud-based platform and a dedicated mobile application. A localized dataset, collected from patients with Type1 and Type2 diabetes using a custom mobile app linked to Google Cloud Platform, was used for model validation. Secure data storage, encryption, and access control measures ensured compliance with international data protection standards. Extensive testing and validation confirmed the robustness, generalizability, and adaptability of the proposed methodologies to diverse clinical scenarios.

This thesis integrates advanced deep learning, generative AI, and cloud computing technologies to tackle fundamental issues in diabetes treatment, providing notable enhancements in accuracy, personalization in glucose forecasting. The results highlight the capacity of these integrated solutions to transform closed-loop diabetes systems, enhancing their accessibility and reliability for patients globally.