Automated Diagnosis and Severity Quantification of Diabetes on Abdominal CT Scans

Abhinav Suri MPH[1,2], Pritam Mukherjee PhD[1], Ronald M. Summers MD PhD[1]

1. Imaging Biomarkers and Computer-Aided Diagnosis Laboratory, National Institutes of Health, Bethesda, MD, USA
2. David Geffen School of Medicine at UCLA, Los Angeles, CA, USA

National Institutes of Health

Introduction

- Diabetes affects millions of individuals in the United States each year.
- However, it is estimated that 17.8% of people who have diabetes are undiagnosed. [1]
- Early diagnosis of diabetes is key to preventing complications.
- **The purpose of this study is to use deep learning on abdominal CT scans to estimate A1c therefore allowing both diagnosis of diabetes and quantification of severity.**

Methods

- Cohort of patients (2005-2023) who had a CT abdomen and an A1c result within 3 months of the scan (822 scans, **580 patients**, 68.6% female, A1c 8.2±2.5(±1SD)%)
- A **convolutional neural network** (DenseNet121 architecture [2]) **was trained** to predict A1c using segmentations of the pancreas and liver (automatically generated from the TotalSegmentator algorithm [3]) as input.
- Learned embeddings from the network were combined with 13 imaging biomarkers automatically derived from liver, pancreas, muscle, and atherosclerotic plaque (mean, median, standard deviation of attenuation, volume of structures) via a Light Gradient Boosting machine model **to predict an A1c**.
- **Figure 1** shows an overview of the architecture. The algorithm was **tested on scans from 290 patients** (1 scan/patient).

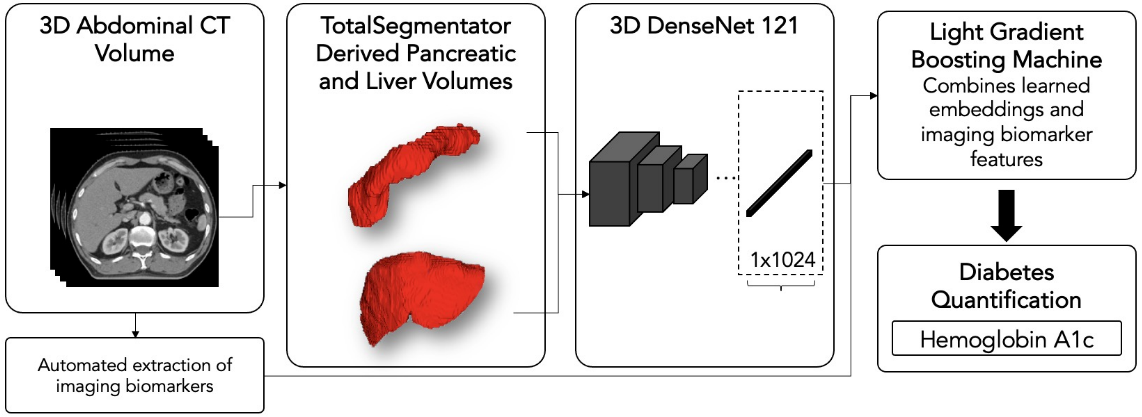

Figure 1: Overview of the network architecture. Abdominal CT scans are input to the TotalSegmentator model to get output volumes for the pancreas and liver. These volumes are then input directly into a 3D DenseNet121 convolutional neural network. Simultaneously, 13 imaging biomarkers are extracted from the CT image and pancreas/liver segmentations and combined with penultimate layer activations/embeddings from the 3D DenseNet (dotted rectangle with bracket) into a Light Gradient Boosting Machine which is trained to output a Hemoglobin A1c.

Results

- The model yielded a mean absolute error in A1c of 0.49±0.40(±1SD)% with a Pearson's R of 0.74 (p<.001, **Figure 2**).
- The Bland-Altman plot showed a mean difference of 0.25±1.14(1.96SD).

Conclusion

- Deep learning on abdominal CT scans can accurately detect and quantify the severity of diabetes without the need for a blood test, enabling opportunistic screening and assessment using prior scans.
- Further testing on a larger patient population is needed to determine this algorithm's performance across all A1c ranges as our dataset contained individuals with higher A1cs.

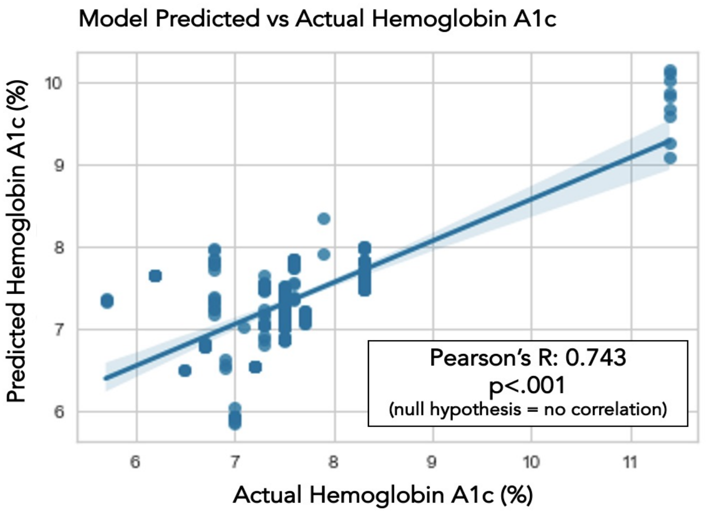

Figure 2: Correlation between model predicted vs actual hemoglobin A1c. Pearson's R and p value are indicated on the graph.

References: **[1]** Fang M, Wang D, Coresh J, Selvin E. Undiagnosed Diabetes in U.S. Adults: Prevalence and Trends. Diabetes Care. 2022 Sep 1;45(9):1994-2002. doi: 10.2337/dc22-0242. PMID: 35817030; PMCID: PMC9472490. **[2]** G. Huang, Z. Liu, L. van der Maaten, and K. Q. Weinberger, "Densely Connected Convolutional Networks." arXiv, Jan. 28, 2018. Accessed: Apr. 08, 2024. [Online]. Available: http://arxiv.org/abs/1608.06993 **[3]** Wasserthal, J., Breit, H. C., Meyer, M. T., Pradella, M., Hinck, D., Sauter, A. W., Heye, T., Boll, D. T., Cyriac, J., Yang, S., Bach, M., & Segeroth, M. (2023). TotalSegmentator: Robust Segmentation of 104 Anatomic Structures in CT Images. Radiology. Artificial intelligence, 5(5), e230024. https://doi.org/10.1148/ryai.230024