Using AI for Predicting Obstructive Sleep Apnoea

Unit Name: Applied Project

Unit Code: CSG3101

Group #: 16

Semester: S2, 2024

Due date: 14/08/2024, 15:00

Supervisor: Dr Syed Mohammed Shamsul ISLAM

Group Members	Student #
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Jon Sveinbjornsson	10396563
Tristan Edward Gardiner	10042832
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Project Goal

The aim of this project is to create an application with an artificial intelligence (AI) deep learning (DL) approach to help identify the occurrence of Obstructive Sleep Apnoea (OSA) syndrome in patients using 3D cranio-facial scans obtained from real life sleep studies.

1.0 Background

On average, a person spends around 27 years of their life sleeping: roughly around a third of their life. The importance of sleep quality has a prevalence on a person's overall physical and physiological health. Insufficient amounts of sleep have been attributed to decreased mental acuity and brain function, a lower life expectancy, growth and development impairment, as well as a higher risk of obesity, cardiovascular disease, and cancer (Shetty & Jardin, 2023). Thus, the importance of sleep studies is important in increasing the overall health and wellbeing of the general population.

One of the more common sleeping disorders is sleep apnoea. Sleep Apnoea can be categorized into two types, central apnoea and obstructive sleep apnoea (OSA). A patient might have one or the other, or a mixture of both (Shetty & Jardin, 2023). Central apnoea occurs when the signal from the brain fails to initiate the body to take a breath, causing a pause in inhalation. Whereas OSA occurs when the body is attempting to breathe air into the lungs, but it is obstructed by the closure of tissues at the base of the tongue, soft palate, and walls of the throat (Shetty & Jardin, 2023). A common measure of apnoea is the apnoea-hypopnea index (AHI), with an index incremented by the number of events that occur within an hour. An event is either an apnoea, characterized by a complete obstruction of the airways for more than ten seconds, or a hypopnea, which is characterized by a partial obstruction to the airways for more than ten seconds (Summer & Singh, 2024). The AHI for adults is 5 to 15 an hour is mild, 15 to 30 per hour is moderate, and any number above 30 is severe. AHI events are important to be recorded as each event indicates a decrease in blood oxygen levels, consequently compounding over time into more severe health issues. The AHI is not the only measure that needs to be recorded during a sleep study as the index can be contradicted, as a patient with a low AHI could have only severe apnoeic events, whereas a patient with a higher AHI might only suffer mild hypopnoeic events (Shetty & Jardin, 2023). Thus, a mixture of different data sets should be obtained and looked at within a single sleep study.

The pathology of apnoea cannot be completely determinant on a single cause with multiple contributing factors being attributed to apnoeic conditions (Shetty & Jardin, 2023; Hanif et al., 2021). Such risk factors include a genetic disposition, gender, age, excessive weight, smoking, alcohol and other drug use, as well as certain craniofacial features. These features include a wider and flatter mid and lower face, a shorter and retracted mandible, and deposition of adipose tissue on the anterior neck (Eastwood et al., 2020). These all contribute to the likeliness of OSA and need to be considered in the diagnosis of this sleeping disorder and the desired treatment. The use of patient questionnaires and both 2D and 3D facial imaging is extremely helpful prior to obtaining sleep study results.

2.0 Scope

The scope of our work is creating a model for predicting OSA in patients based on 3D images provided by the user that can be processed in an application. The application itself will have both a front and back end be runnable in a local development environment. In addition to the model and user interface, extensive documentation and user guides will be provided as the application itself is being deployed live.

2.1 Project Requirements

The project requires the collection and preprocessing of 3D cranial scans and sleep study data, followed by the development of a deep learning model for analysis, comprehensive testing and validation of the DL model, and the creation of a simple web interface for data upload and prediction result display. Specifically, the tasks include acquiring data from clients and clinical sources, preparing the data for effective model training, developing an accurate deep learning model, conducting thorough testing and validation, and implementing a user-friendly interface for interacting with the model.

1. **Data collection and preprocessing:**
    - **a.** Acquire data from client of 3D cranial scans and sleep study data from clinical sources.
    - **b.** Prepare the data for effective training of the DL model by preprocessing the 3D scans.
2. **AI Model:**
    - a. Select and implement a deep learning model to analyse the 3D image dataset (with an accuracy to the best of our abilities and limitations on the data size).
3. **AI Model Testing and Validation:**
    - **a.** Conduct comprehensive testing of the application, recording training, validation, and test accuracy rates.
4. **Web Interface:**
    - a. A simple user interface that allows a user to upload data and have it analysed by the model, returning the prediction result generated.

2.2 Project Deliverables

Deliverable	Description
Final Predictive System	A web interface capable of analysing 3D image data to predict OSA events.
Source Code	Zipped content containing files with program source code in GitHub.
User Manual	A step-by-step guide to run the application.
Developer Manual	Readme.md
Data	The raw data collected and used for the program.

Project Report	A comprehensive report discussing the theory of the AI method used, how it was implemented, and summarising the validation results and performance metric.
Literature Review (optional)	A review paper on the most recent research findings on using 3D scans for the identification of OSA.
Project Demo/Prototype	A working demonstration of the program to showcase its capabilities.

3.0 Schedule

Milestones Linked to Deliverables:
Week 4: Project Proposal Submitted
Week 7: Literature Review Submitted
Week 10: Prototype Completed
Week 12: Final Project Submission (including Predictive System, Source Code, User Manual, Developer Manual, Data Collection, Project Report, Project Demo)

As our group has varying levels of experience with programming and many members want to participate in the development of the prediction model, we will allocate time weekly to do team programming exercises and knowledge exchanges on the tools needed. This includes the libraries and frameworks for the development of both the prediction model and the user interface. We have decided to set an earlier date for a complete and working deliverable prototype, that being week 10. This will allow the team to experiment new architectures of the model, eliminating the need for delivering the project in incremental steps, providing the chance for a potential continued improvement in accuracy.

In the project timeline, the deliverables are respective to their ending blocks. Week 4, the project proposal is finished, week 7 the literature review, week 10 the complete prototype will be finished, allowing 2 weeks for documentation, experimentation and refinement. The most important parts of this project are the data acquisition, the model and its performance, and the user interface. The data acquisition is the current bottleneck as a model cannot be developed until the dataset is acquired. The client has the current dataset and will deliver this by the end of week 4. Team members are participating in the gathering of more data to enlarge the dataset. If the dataset is not delivered on time, the project schedule should not be dramatically affected, as 2 weeks for refinement have been added to the tail of the project, which can be used for development instead.

4.0 Team Capability Alignment

For each team member, what will be their role, what course are they enrolled in, and which of their Course Learning Outcomes align with the tasks they will be completing.

Name	Study	Role
Mahathir Abdul Basher	U65 Bachelor of Computer Science - Software Engineering	Dataset collector, Developer (AI Model), Writer (Model approach, performance evaluation)
Jon Sveinbjornsson	U65 Bachelor of Computer Science - Software Engineering	Developer (Full stack, AI Model), Writer (Application documentation & User manual, Literature review)
Tristan Edward Gardiner	U65 Bachelor of Computer Science - Software Engineering	Developer (AI Model, General Tasks), Writer (Literature review, Project Report)
Steven Cobain	Y89 Bachelor of Cyber Security	Writer (Literature review, Project Report)
Xiayu Huang	U65 Bachelor of Computer Science - Software Engineering	Developer (Full stack, AI Model, general tasks)

5.0 Tools and Technical Requirements

To complete this project, we will require the normal tools needed for software engineering, those being an IDE of each developer's choice, programming languages, frameworks and machines with a GPU for training the model. The proposed languages for development are currently Python, for the Model development, TS.ed for the UI and backend, and SwaggerUI for documentation. Git and GitHub also be used for version control and team participation tracking.

References

Hanif, U., Leary, E., Schneider, L., Paulsen, R., Morse, A. M., Blackman, A., Schweitzer, P., Kushida, C. A., Liu, S., Jennum, P., Sorensen, H., & Mignot, E. (2021). Estimation of Apnea-Hypopnea Index Using Deep Learning On 3-D Craniofacial Scans. IEEE Journal of Biomedical and Health Informatics, 25(11). https://doi.org/10.1109/JBHI.2021.3078127

Shetty, A., & Baptista Jardín, P. M. (2023). *A patient's guide to obstructive sleep apnea syndrome*. Springer. https://doi.org/10.1007/978-3-031-38264-2

Summer, J.,& Singh, A. (2024, January 2). Apnea-Hypopnea Index (AHI). https://www.sleepfoundation.org/sleep-apnea/ahi

Appendix A

Group Contract

1. The subject matter of this contract

This contract is entered into by the students named below for the purpose of ensuring that each individual group member fulfills his/her obligations for completing the group assignment for the unit CSG3101 Applied Project.

2. The consideration

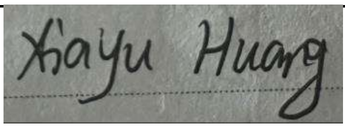
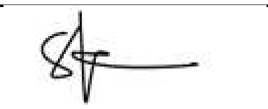
1. All group members will be punctual at meetings.
2. All group members should attend meetings unless by prior agreement with the group.
3. All group members will stay at the meeting until it is agreed that the meeting is adjourned.
4. All group members will agree to a specific day/time for each weekly meeting and an agreed procedure for informing all other members prior to any missed meetings.
5. All group members will come to the meetings prepared by completing the agreed tasks on time.
6. The group will actively seek the contributions and opinions of each member at meetings and during group discussions.
7. Each group member will take turns at both listening and talking.
8. Dominating the group's discussion and decision making is not acceptable.
9. Group members will take turns in writing down minutes of the meeting.
10. The group member taking minutes will record allocated tasks to be completed by group members by name and agreed deadlines for task completion.
11. The group members must decide and declare which method of communication is to be the preferred and agreed method (i.e., MS Teams, ECU email, face-to-face.
12. The group members must decide on an auditable and verifiable method of detailing completed tasks and or individual elements. (i.e., Google groups, tasks management, written master file)
13. Work allocation will be according to an agreed procedure and is documented below:
    a. *Teams meetings discussion in which group members choose what tasks they would like to complete according to their experience.*
14. Where disputes arise regarding the work tasks or agreed behaviours in which a group member is not performing according to the terms of this agreement, the following process will be entered into to resolve the dispute:

a. A group discussion about how to move forward as a group. Disputes must be resolved within the group and documentation must be retained that relates to attempts to resolve a dispute or to encourage a group member to make his or her contribution to the assignment).

15. Ejection of a non-performing or disruptive group member. The Contract MUST include a specific method for dealing with group members where the performance of the group is affected.

a. The method for dealing with a non-performing or disruptive group member will be immediate contact with both Dr. Shams and Mr Derek Tighe to report behaviour of the group member and how to proceed with a formal ejection of the contract violating group member.

<u>3. Names and signatures of the parties to this Group Contract</u>

Student signature	Student name (printed)	Student Number	Date
	Mahathir Abdul Basher	10560535	05/08/2024
	Tristan Edward Gardiner	10042832	05/08/2024
	Jon Sveinbjornsson	10396563	05/08/2024
	Xiayu Huang	10508752	13/08/2024
	Steven Cobain	10475725	14/08/2024

Date of Fully Signed copy given to Supervisor and Unit Coordinator

____________14/08/2024______________