**A signal processing framework for sleep stage classification using EEG brainwave dynamics and rule-based inference**

*An Undergraduate Project Report submitted to Manipal Academy of Higher. Education in partial fulfilment of the requirement for the award of the degree of………….*

**BACHELOR OF TECHNOLOGY**

**In**

**Biomedical Engineering**

*Submitted by*

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**May 2025**



**Manipal**

**22nd May 2024**

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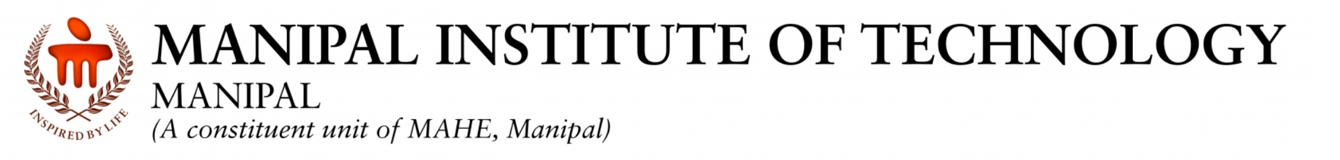
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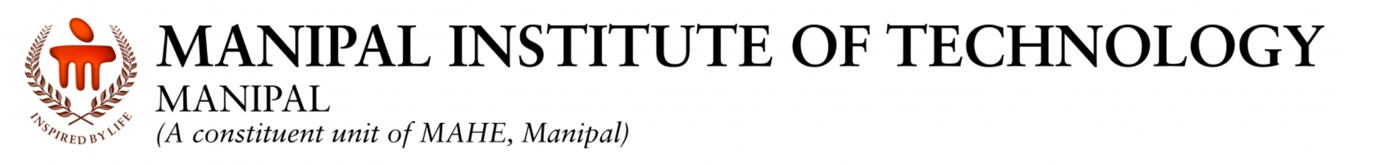
***Project Guide***

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| CONTENTS | | | | | Page No. |
| Acknowledgements | | | |  | **i** |
| Abstract | | | |  | **ii** |
| List of Figures I | | | |  | **iii** |
| List of Figures II | | | |  | **iv** |
| Chapter 1 | | | **INTRODUCTION** | | **1 - 6** |
|  | **1.1** | Examination of Foundational Elements within the Subject Matter | | | 1 |
|  | **1.2** | EEG-Based Sleep Stage Classification | | | 2 |
|  | **1.2.1** | Characterize EEG Brainwave Dynamics Across Sleep Stages | | | 2 |
|  | **1.2.2** | Examine Stage Transitions and Temporal Overlaps in Brainwave Activity | | | 3 |
|  | **1.2.3** | Enhance Rule-Based Classifier, Develop Hypnograms, and Assess Performance | | | 3 |
|  | **1.3** | Summary of work done | | | 4 |
|  | **1.4** | Rationale of the Work | | | 5 |
|  | **1.5** | Organisation of the report | | | 6 |
|  | | | | |  |
| Chapter 2 | | | **LITERATURE REVIEW** | | **7- 13** |
|  | **2.1** | Examination of Sleep EEG Patterns and Identification of Sleep Stages | | | 7 |
|  | **2.2** | Power Spectral Density (PSD) Using Welch’s Method | | | 8 |
|  | **2.3** | Examination of Signal Amplitude through Hilbert Transform Techniques | | | 9 |
|  | **2.4** | Hypnograms and Categorization of Sleep Stages | | | 9 |
|  | **2.5** | Rule-Based Classification Models | | | 10 |
|  | **2.6** | Feature Extraction: Spindles, K-Complexes, and Bursts | | | 11 |
|  | **2.7** | Challenges and Gaps in Existing Approaches | | | 12 |
|  | **2.8** | Deep learning methods for sleep stage classification | | | 12 |
|  | **2.9** | Integration with Ongoing Work | | | 13 |
|  | | | | |  |
| Chapter 3 | | | **METHODOLOGY** | | **15-26** |
|  | **3.1** | Data Set Overview | | | 15 |
|  | **3.1.1** | Dataset Composition | | | 17 |
|  | **3.1.2** | Signals and Annotations | | | 17 |
|  | **3.2** | Preprocessing | | | 17 |
|  | **3.3** | Analysis Techniques and Feature Extraction | | | 18 |
|  | **3.3.1** | Butterworth Bandpass Filtering | | | 18 |
|  | **3.3.2** | Time-Domain analysis | | | 19 |
|  | **3.3.3** | Spectral Power Analysis (Welch’s PSD) | | | 20 |
|  | **3.3.4** | Short-Time Fourier Transform (STFT) | | | 21 |
|  | **3.3.5** | Amplitude Analysis (Hilbert Transform) | | | 22 |
|  | **3.4** | Platform and Development Environment | | | 23 |
|  | **3.5** | Classification Rules | | | 24 |
|  | **3.5.1** | Classification Process | | | 24 |
|  | **3.6** | Hypnogram Generation and Validation | | | 26 |
|  | **3.7** | Expected Outcomes | | | 26 |
|  | | | | |  |
| Chapter 4 | | | **RESULTS** | | **28 - 62** |
|  | **4.1** | Time Analysis | | | 28 |
|  | **4.1.1** | Creation of Hypnograms Through YASA Classifier Application | | | 28 |
|  | **4.1.2** | Deriving time stamps for sleep stages | | | 28 |
|  | **4.1.3** | Detailed Examination of Sleep Stage Durations Within 39 EDF Files | | | 30 |
|  | **4.1.4** | Interpretation of Sleep Stage Duration and Distribution | | | 32 |
|  | **4.1.5** | Examination of Sleep Stage Percentages through Statistical Summaries and Outlier Detection | | | 33 |
|  | **4.2** | Examining amplitude variations | | | 34 |
|  | **4.2.1** | Overview and Rationale | | | 34 |
|  | **4.2.2** | Signal Preprocessing | | | 34 |
|  | **4.2.3** | Sleep stage amplitude | | | 34 |
|  | 4.2.4 | N1 Sleep Stage | | | 35 |
|  | 4.2.5 | N2 Sleep Stage | | | 37 |
|  | **4.2.6** | N3 Sleep Stage | | | 38 |
|  | **4.2.7** | REM Sleep Stage | | | 40 |
|  | **4.2.8** | Comparative Summary Across Stages | | | 41 |
|  | **4.2.9** | Channel Comparison | | | 41 |
|  | **4.2.10** | Conclusion | | | 42 |
|  | **4.3** | Examination of Power Spectral Density through Welch’s method | | | 42 |
|  | **4.3.1** | Overview and motivation | | | 42 |
|  | **4.3.2** | Processing Steps | | | 43 |
|  | **4.3.3** | Analysis from the Pz-Oz Channel | | | 43 |
|  | **4.3.3.1** | Absolute Power Estimation | | | 43 |
|  | **4.3.3.2** | Relative Power Calculations | | | 44 |
|  | **4.3.3.3** | Band Ratio Calculation | | | 44 |
|  | **4.3.4** | Analysis from Fpz-Cz Channel | | | 50 |
|  | **4.3.4.1** | Absolute Power Estimation | | | 50 |
|  | **4.3.4.2** | Relative Power Calculations | | | 50 |
|  | **4.3.4.3** | Band Ratio Calculation | | | 50 |
|  | **4.3.5** | Stage-wise Observations and Interpretation | | | 51 |
|  | **4.3.6** | Chanel Comparison and summary | | | 57 |
|  | **4.3.7** | Conclusion | | | 57 |
|  | **4.4** | Rule-Based Classification of Sleep Stages | | | 57 |
|  | **4.4.1** | Overview and Objective | | | 57 |
|  | **4.4.2** | Preprocessing and Feature Extraction | | | 57 |
|  | **4.4.3** | Rule-Based Classifier Design | | | 58 |
|  | **4.4.4** | Classifier Evaluation Across Multiple Subjects | | | 60 |
|  | **4.4.5** | Interpretability and Justification | | | 62 |
|  | | | | |  |
| Chapter 5 | | | **CONCLUSION** | | **64 - 36** |
|  | **5.1** | Work Overview | | | 64 |
|  | **5.2** | Limitations | | | 65 |
|  | **5.3** | Future Scope of Work | | | 66 |
|  | **5.3.1** | Event-Based Feature Integration for Spindles K-Complexes K-Waveforms Burst Activity | | | 66 |
|  | **5.3.2** | Multi-Modal Signal Integration | | | 67 |
|  | **5.3.3** | Advanced Temporal Modelling | | | 67 |
|  | **5.3.4** | Adaptation to Disordered Populations: | | | 67 |
|  | **5.3.5** | Complex Real-Time Implementation in Wearable Technology Systems | | | 67 |
|  | **5.3.6** | Hybrid Classification Models | | | 67 |
|  | **5.3.7** | Validation on diverse Datasets | | | 67 |
|  | **5.3.8** | Clinical Integration | | | 68 |
|  | | | | |  |
| REFERENCES | | | | | **69- 70** |
| ANNEXURES | | | | |  |
| PROJECT DETAILS | | | | | **71** |



**ACKNOWLEDGEMENTS**

We express our deepest gratitude to our project guide, Dr. Amritanshu Gupta, Assistant Professor - Senior Scale in the Department of Biomedical Engineering at Manipal Institute of Technology, Manipal, for his expert guidance and unwavering support in developing the signal processing framework for sleep stage classification using EEG brainwave dynamics. His insights and feedback were invaluable in shaping this research.

We are also deeply thankful to Dr. Niranjana Sampathila, Professor and Head of the Department of Biomedical Engineering, for providing the necessary resources and creating an environment conducive to research and learning.

Our appreciation extends to the faculty and staff of the Department of Biomedical Engineering at Manipal Institute of Technology, Manipal, for their assistance and cooperation throughout the project.

We are grateful to Manipal Institute of Technology, Manipal, a constituent college of Manipal Academy of Higher Education, for providing an excellent academic environment and the opportunity to undertake this project.

Additionally, we thank the providers of the Sleep-EDF Database Expanded (2013) from PhysioNet, which was crucial for our data analysis, and the developers of the YASA library and other open-source tools, including mne, scipy, numpy, pandas, matplotlib, seaborn, scikit-learn, and statsmodels, which facilitated our research.

Finally, we extend our heartfelt thanks to our families and friends for their constant encouragement and understanding during this endeavor.

**ABSTRACT**

The investigation introduces a signal processing framework designed for automated sleep stage classification utilizing EEG data from the Sleep-EDF Database Expanded (2013). The framework employs full-night recordings from 39 subjects’ Fpz-Cz and Pz-Oz channels to segment EEG signals into 30-second epochs which it then decomposes into Delta (3–4 Hz), Theta (4–8 Hz), and Alpha (8–12 Hz) bands through Butterworth bandpass filters. The YASA library extracts features including band powers and ratios like Alpha/(Theta+Delta) along with event-based markers such as sleep spindles and K-complexes for analysis. The rule-based classifier with temporal smoothing records a 70% adjusted accuracy when tested against expert-annotated hypnograms. The classifier demonstrates strong performance in detecting N3 (precision ~0.75–0.80) and REM stages (recall ~0.70–0.75) while it faces difficulties with N1 stage detection (recall ~0.50–0.60) because of spectral overlap with wakefulness signals. This framework presents a lightweight interpretable option that stands as an alternative to resource-heavy deep learning models (accuracy 84–92%) while adhering to American Academy of Sleep Medicine (AASM) standards to decrease subjective elements in manual polysomnography scoring (Cohen’s kappa ~0.68–0.76) and supports scalable sleep research and clinical diagnostics for conditions such as insomnia and sleep apnea.

**KEYWORDS:**

Sleep Stage Classification, Electroencephalography (EEG), Signal Processing, Rule-Based Classifier, Polysomnography (PSG), Sleep Disorders, American Academy of Sleep Medicine (AASM) Guidelines

**LIST OF FIGURES**

|  |  |  |
| --- | --- | --- |
| **Figure No** | **Figure Title** | **Page No** |
| 2.1 | Hypnogram illustrating DeepSleepNet’s automated sleep stage predictions | 8 |
| 2.2 | Hypnogram comparing SleepEEGNet’s automated sleep stage predictions | 10 |
| 2.3 | EEG traces with spindle annotations from expert and automated methods | 11 |
| 3.1 | Flowchart of the Sleep Stage Classification Pipeline | 16 |
| 3.2 | Butter Butterworth Bandpass Filtering Flowchart | 19 |
| 3.3 | Time-Domain Analysis Flowchart | 20 |
| 3.4 | Welch’s PSD Flowchart | 21 |
| 3.5 | STFT Flowchart | 22 |
| 3.6 | Hilbert Transform Flowchart | 23 |
| 3.7 | Rule based classification | 27 |
| 4.1 | YASA Generated Hypnogram | 28 |
| 4.2 | Full Recording of Sleep Signal for Extraction of Time Stamps across Different Sleep Stages | 29 |
| 4.3 | frequency band analysis from Fpz-Cz electrode. Top: Original signal (41000-41010 s). | 35 |
| 4.4 | Segment-wise Hypnogram Generation for 1 Subject | 60 |
| 4.4.4(a) | Hypnogram Generation of 5 different subjects with comparison | 61 |
| 4.4.4(b) | Confusion Matrix to show Overall Accuracy and different sleep stage comparisons. | 62 |
| 4.4.4(c) | Comparison between Expert and Predicted Hypnogram for complete Sleep duration. | 62 |

**LIST OF TABLES**

|  |  |  |
| --- | --- | --- |
| **Figure No** | **Figure Title** | **Page No** |
| 1 | Summary Table of Objectives and Key Tasks | 4 |
| 2 | Sleep Stage Time-Intervals | 30 |
| 3 | Summary of Sleep stage Durations and Percentages | 31 |
| 4 | Statistical Summary of Sleep Stage Percentages and Identification of Outliers | 33 |
| 5 | Mean Amplitude of N1 Sleep Stage | 36 |
| 6 | Mean Amplitude of N2 Sleep Stage | 37 |
| 7 | Mean Amplitude of N3 Sleep Stage | 39 |
| 8 | Mean Amplitude of REM Sleep Stage | 40 |
| 9 | Absolute and Relative Band powers and Ratios for N1 Sleep Stage for Pz-Oz | 45 |
| 10 | Absolute and Relative Band powers and Ratios for N2 Sleep Stage for Pz-Oz | 46 |
| 11 | Absolute and Relative Band powers and Ratios for N3 Sleep Stage for Pz-Oz | 47 |
| 12 | Absolute and Relative Band powers and Ratios for REM Sleep Stage for Pz-Oz | 48 |
| 13 | Absolute and Relative Band powers and Ratios for N1 Sleep Stage for Fpz-Cz | 51 |
| 14 | Absolute and Relative Band powers and Ratios for N2 Sleep Stage for Fpz-Cz | 53 |
| 15 | Absolute and Relative Band powers and Ratios for N3 Sleep Stage for Fpz-Cz | 54 |
| 16 | Absolute and Relative Band powers and Ratios for REM Sleep Stage for Fpz-Cz | 55 |
| 17 | Summary of the Limitations | 66 |