

## TABLE OF CONTENTS

|  |     |
|--|-----|
| ABSTRACT .....   | iv  |
| PUBLISHED WORK.....  | vi  |
| TABLE OF CONTENTS .....  | vii |
| LIST OF TABLES .....   | ix  |
| LIST OF FIGURES.....   | x   |
| Chapter 1 .....  | 1   |
| INTRODUCTION AND LITERATURE REVIEW .....                         | 1   |
| 1.1 <b>Human Motion Prediction</b> .....                         | 1   |
| 1.2 <b>Recurrent Neural Networks and Motion Prediction</b> ..... | 2   |
| 1.3 <b>Motion Data</b> .....                                     | 5   |
| 1.4 <b>Overview of Motion Capture Data</b> .....                 | 6   |
| 1.2.3 <b>MOCAP File Formats</b> .....                            | 7   |
| 1.5 <b>Literature Review</b> .....                               | 12  |
| Chapter 2 .....  | 15  |
| DEEP LEARNING.....   | 15  |
| 2.1 <b>Introduction</b> .....                                    | 15  |
| 2.2 <b>Machine learning vs deep learning</b> .....               | 17  |
| 2.3 <b>Machine learning categories</b> .....                     | 18  |
| 2.4 <b>Neural Networks</b> .....                                 | 20  |
| 2.4.1 <b>Activation Functions</b> .....                          | 24  |
| 2.4.2 <b>Neural Networks in Action</b> .....                     | 28  |
| 2.4.3 <b>Vectorization in Neural Networks</b> .....              | 40  |
| Chapter 3 .....  | 43  |
| RECURRENT NEURAL NETWORKS .....                                  | 43  |
| 3.1 <b>Introduction</b> .....                                    | 43  |
| 3.2 <b>RNN Activation Functions</b> .....                        | 47  |
| 3.3 <b>RNN Loss Function</b> .....                               | 48  |
| 3.4 <b>RNNs in Action</b> .....                                  | 48  |
| 3.5 <b>Vanishing and Exploding Gradients</b> .....               | 54  |

|       |  |     |
|-------|--|-----|
| 3.6   | <b>Gated RNNs</b> .....  | 55  |
| 3.6.1 | <b>Long Short-Term Memory - LSTM</b> .....                     | 55  |
| 3.6.2 | <b>Gated Recurrent Unit – GRU</b> .....                        | 60  |
| 3.7   | <b>Residual Connections</b> .....                              | 62  |
| 3.8   | <b>Gradient Clipping</b> .....                                 | 65  |
| 3.9   | <b>RNN Architectures</b> .....                                 | 67  |
| 3.10  | <b>Bidirectional Recurrent Neural Networks</b> .....           | 69  |
| 3.11  | <b>Encoder-Decoder Sequence-to-Sequence Architecture</b> ..... | 72  |
| 3.12  | <b>Attention Mechanism</b> .....                               | 74  |
|       | Chapter 4.....   | 76  |
|       | MATERIALS AND METHODS.....                                     | 76  |
| 4.1   | <b>Materials</b> .....   | 76  |
| 4.1.1 | <b>Human3.6 Dataset</b> .....                                  | 76  |
| 4.2   | <b>Methods</b> .....   | 81  |
| 4.2.1 | <b>Model Architecture</b> .....                                | 83  |
| 4.2.2 | <b>Encoder</b> .....   | 84  |
| 4.2.3 | <b>Decoder</b> .....   | 86  |
| 4.2.4 | <b>Model Implementation</b> .....                              | 88  |
|       | Chapter 5.....   | 98  |
|       | EXPERIMENTS AND RESULTS.....                                   | 98  |
| 5.1   | <b>Experimental Setup</b> .....                                | 98  |
| 5.1.1 | <b>Environmental Specifications of the Experiment</b> .....    | 98  |
| a)    | <b>Hardware</b> .....  | 98  |
| b)    | <b>Software</b> .....  | 98  |
| 5.1.2 | <b>Experimentations of this Work</b> .....                     | 99  |
| a)    | <b>Hyperparameters</b> .....                                   | 100 |
| b)    | <b>Architecture and algorithm implementation details</b> ..... | 100 |
| 5.1.3 | <b>Results</b> .....   | 101 |
| 5.1.4 | <b>Discussion</b> .....  | 105 |
| 5.1.5 | <b>Conclusion</b> .....  | 106 |
| 5.1.6 | <b>Future work</b> .....                                       | 107 |
|       | REFERENCES.....  | 108 |