**LIST OF FIGURES**

<table>
<thead>
<tr>
<th>Figure No.</th>
<th>Description</th>
<th>Page No.</th>
</tr>
</thead>
<tbody>
<tr>
<td>3.1</td>
<td>System Architecture</td>
<td>16</td>
</tr>
<tr>
<td>3.2</td>
<td>The gesture pad and various gestures</td>
<td>18</td>
</tr>
<tr>
<td>3.3</td>
<td>Sample floor plan illustrating the LARN algorithm</td>
<td>19</td>
</tr>
<tr>
<td>3.4</td>
<td>Various shortest paths</td>
<td>20</td>
</tr>
<tr>
<td>4.1</td>
<td>Mudra System Architecture</td>
<td>26</td>
</tr>
<tr>
<td>4.2</td>
<td>gpaD architecture</td>
<td>26</td>
</tr>
<tr>
<td>4.3</td>
<td>gpaD as implemented</td>
<td>27</td>
</tr>
<tr>
<td>4.4</td>
<td>Suggested Gestures</td>
<td>27</td>
</tr>
<tr>
<td>4.5</td>
<td>(a) Success PDF and (b) Failure PDF</td>
<td>30</td>
</tr>
<tr>
<td>4.6</td>
<td>Hand Rotation With Respect To The Wrist</td>
<td>31</td>
</tr>
<tr>
<td>4.7</td>
<td>Gestures Vs Response Time</td>
<td>36</td>
</tr>
<tr>
<td>4.8</td>
<td>The ramp measurements</td>
<td>39</td>
</tr>
<tr>
<td>4.9</td>
<td>(a) - (b). Two versions of Mudra where the a prototype gpaD is attached to the wheelchair</td>
<td>41</td>
</tr>
<tr>
<td>4.10</td>
<td>Stroke patient 1 who is undergoing physiotherapy as part of rehabilitation process at Rehab. Dept. of AIMS testing the gesture controlled Mudra.</td>
<td>42</td>
</tr>
<tr>
<td>4.11</td>
<td>Stroke patient 2 who is undergoing physiotherapy as part of rehabilitation process at Rehab. Dept. of AIMS testing the gesture controlled Mudra.</td>
<td>42</td>
</tr>
</tbody>
</table>
4.12 Stroke patient 3 who is undergoing physiotherapy as part of rehabilitation process at Rehab. Dept. of AIMS testing the gesture controlled Mudra.

5.1 IR Camera Based Hand Gesture Navigation Control Wheelchair System Architecture

5.2 (a). Hardware setup of the system as in Phase I

5.2 (b). Hardware setup of the system as in Phase I

5.3 Hand position showing the Ulnar Deviation and the Normal Radial Deviation. The deviation is with respect to the wrist at fixed neutral position

5.4 Gestures

5.5 Wheelchair control GUI in MATLAB

5.6 The system setup as in Phase II

5.7 Comparison of the gesture capture boxes in Phase I and Phase II.

5.8 Intel Atom Processor EBC 352 connected with SATA HD

5.9 Snapshot of QT IDE in Ubuntu

5.10 GUI with various commands

5.11 Final Setup of the system as in Phase III

5.12 Gesture Capture Module with a opening shown. The user inserts the hand into this opening to show the hand gestures to control navigation

5.13 Inside GCM Shows the user hand gesture. The user places the hand over a smooth glass plate under which is fixed the IR led array.

5.14 The final version of the system setup
5.15 Time taken in (sec) for reverse gesture Vs Correlation value
5.16 Time taken in (sec) for forward gesture Vs Correlation value
5.17 Response time for gesture movement from Brake to reverse
5.18 Response time for gesture movement from reverse to forward
5.19 Response time for gesture movement from brake to right
5.20 Response time for gesture movement from None to Left
5.21 Time taken for various gesture changes with and without jerks
5.22 Time taken for various gesture changes with Intel Core 2 Duo and Atom processors
5.23 Correlation value Vs Response time. The best response time for any of the four gestures is always for a correlation value of 0.65
5.24 Gesture changes success percentage. The average success percentage is above 98%
5.25 Gestures Vs Response Time
5.26 The final model of IR camera based hand gestured controlled wheelchair
5.27 The initial IR camera based hand gestured controlled wheelchair
5.28 The IR camera based hand gestured controlled wheelchair with a user testable wheelchair setup
5.29 The IR camera based hand gestured controlled wheelchair in action
5.30 The IR camera based hand gestured controlled wheelchair in action with the user controlling the wheelchair
5.31 Another version of IR camera based hand gestured controlled wheelchair where the GRM is placed behind the wheelchair

5.32 Final version of IR camera based hand gestured controlled wheelchair

5.33 Final version of IR camera based hand gestured controlled wheelchair with a user

6.1 Block diagram of Automatic Navigation Controller

6.2 Architecture Diagram of Automatic Navigation Controller

6.3 The Automatic Navigation Controller Flow Chart

6.4 Sample floor plan

6.5 Matrix representation of the grids

6.6 Result of LARN algorithm

6.7 Visual representation of the path to grid (1,3)

6.8 The four basic directions are shown for a 5 X 5 grid indoor plan

6.9 Commands involved in normal operation

6.10 Commands involved after obstacle detection

6.11 Time duration to rotate from North to East at 22% PWM

6.12 Error in final value in rotating from North to East at 22% PWM

6.15 Time duration to rotate from North to East at 12% PWM

6.15 Error in Final value in rotating from North to East at 12% PWM

6.16 Floor plan of test environment
7.18 EOG waveform for looking Left, Straight and right 143
7.19 Waveform obtained for Pulse-oximetry 144
7.20 ECG waveform obtained on the oscilloscope 145
7.21 Measuring Rpk-Rpk from the waveform obtained 146
7.22 Integrated circuit on wheelchair 147
7.23 ECPMS System With User Testing PMS 148
7.24 ECPMS System With User Testing EOG Control 148
8.1 Architecture Diagram 151
8.2 LARN Algorithm Flowchart Part I 154
8.3 LARN Algorithm Flowchart Part II 155
8.4 Floor Plans of Various Shapes and Sizes 158
8.5 An example floor plan with three sources/destinations and the possible shortest paths 159
8.6 Another example floor plan with five sources/destinations and the possible shortest paths. 159
8.7 The first step of the GUI allows the user to create a new floor plan or use an existing one 162
8.8 In the second step of GUI, the user can set rotation error, wheel alignment error, simulate with and without error, generate the report etc. 162
8.9 (a) - (d) Sample Floor Plans created using the simulator 163
8.10  Plot between the number of grids traversed and the time taken to reach the destination

8.11  Time difference between the simulation time and navigation time

8.12  Each of the figures (a1) to (a27) represent the house floor plan

8.13  Sample floor plan simulation with fixed shape and size and static obstacles included

8.14  Plot between the number of grids traversed and the time taken to reach the destination

8.15  Time difference between the simulation time and navigation time

8.16  Simulation Timings with and without Dynamic Obstacles to reach Destination D1 from Source S, as shown in Figure 8.20 (a1) - a(27)

8.17  Simulation Timings with and without Dynamic Obstacles to reach Destination D2 from Source S, as shown in Figure 8.20 (a1) - a(27)

8.18  Simulation Timings with and without Dynamic Obstacles to reach Destination D3 from Source S, as shown in Figure 8.20 (a1) - a(27)

8.19  Dynamic obstacle verses difference in the simulation time between Fixed Path case and Hybrid Path case

8.20  Each of the figures a1 to a27 represent the house floor plan

8.21  Dynamic obstacle verses difference in the simulation time between Fixed Path case and Dynamic Path case

8.22  Each of the figures a1 to a27 represent the house floor plan

8.23  Each of the figures a1 to a27 represent the house floor plan