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Artificial Intelligence Driven Tilt Sensor Based Smart Drinking Device for Stroke Survivors

Session 4 – 4.3

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Session #XXXX

Introduction

Challenges

- Stroke causes upper limb dysfunction in 40-80% of survivors, affecting hand and arm movements.
- This impacts tasks like drinking, where survivors struggle to hold and lift glasses.
- Rehabilitation is costly, infrastructure-heavy, and requires long-term support

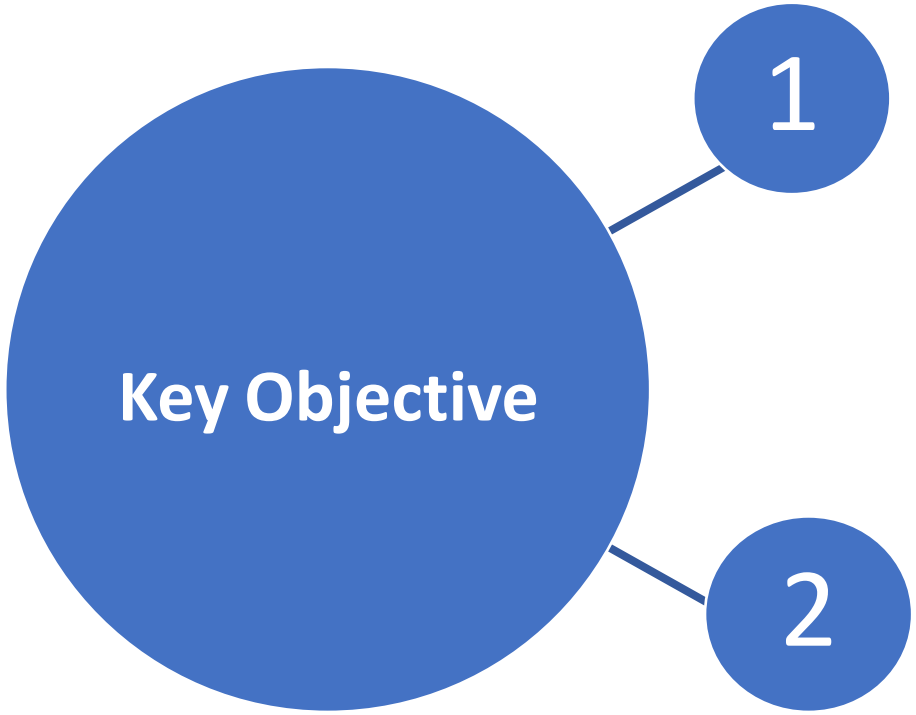
Current Solution

- Few tools are available for monitoring glass orientation in real time during drinking activities.
- Existing assistive devices focus on general hand movement but fail to provide specific feedback on glass orientation during drinking activities
- No existing devices provide specific feedback on how to stabilize a glass to prevent spills.

Proposed Solution

- Development of a Tilt Sensor Device to monitor glass orientation during drinking tasks, offering real-time feedback to stroke survivors.
- The device uses a gyroscope and accelerometer to track glass tilt and provides alerts through a color-coded LED system.
- Aimed at enhancing motor control and reducing spills, the device is designed to improve rehabilitation outcomes by providing immediate, actionable feedback to the user.

Key Objective



To design a sensing device with a that tracks glass orientation. Integrate the sensor with AI and IoT to deliver personalized rehabilitation strategies and continuous monitoring.

To evaluate the reliability and effectiveness of the proposed device for stroke survivors during drinking tasks. Measure the device's ability to provide real-time feedback to improve motor control and reduce glass spills.

Device Design and Components

Design Overview

The device is attached to a drinking glass to monitor its orientation.

Developed using CAD tools for electronic enclosure and 3D printed for a custom fit.

Integrated with IoT technology for real-time data transmission.

Key Components

MPU6050: A gyroscope and accelerometer for tracking the glass's tilt and orientation.

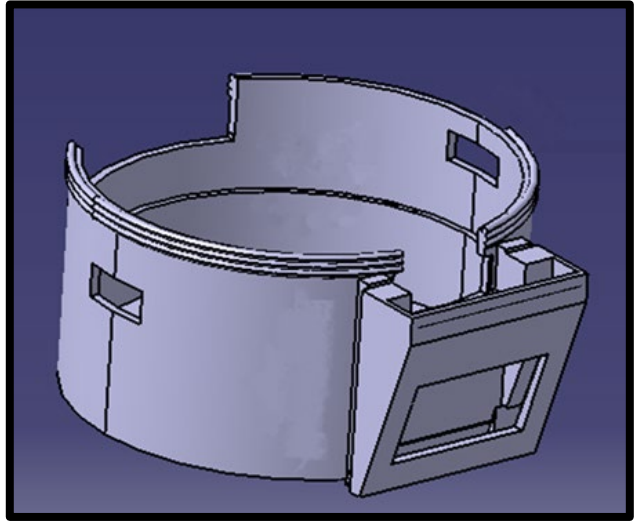
Node MCU: A microcontroller with built-in Wi-Fi for wireless communication.

Lithium Polymer Battery: Rechargeable battery to power the device.

TP4056 Module: Battery charger for easy recharging.

LED Indicators: Provide visual feedback for tilt angles (Green for 0-20°, Yellow for 21-30°, Orange for 31-50°, Red for >50°).

ON/OFF Switch: Controls the power to the device



CAD Model of Electronics Enclosure

Developed device with fastener

Patent Application No. 202341045175 – Status (Published)

Working Principle

1. **Activation**

   Device is switched on when glass is lifted

2. **Tracking**

   Sensor tracks glass orientation relative to zenith angle

3. **Feedback**

   LEDs illuminate based on predefined threshold values

4. **Data Transmission**

   Orientation and movement data sent to cloud platform

Participation and Selection Criteria

Selection Process:

- Participants were recruited from stroke rehabilitation centers, physiotherapy OPDs, and neuro-physiotherapy clinics.
- Approval is obtained from the Ethical Committee before conducting the study.
- Both healthy individuals and stroke survivors were included in the study.

Inclusion Criteria:

Healthy Individuals:

- Age 18 and above
- Full active range of motion (ROM) of the upper limb.

Stroke Survivors:

- Diagnosed stroke confirmed by clinician and MRI/CT.
- Age 18 and above, in sub-acute (3-26 weeks) or chronic stage (>12 months).
- Ability to sit independently.

Exclusion Criteria:

For Both Groups:

- Individuals with ROM restrictions in the wrist/hand, complaints of pain, fractures, or dislocations.
- Other neurological or musculoskeletal disorders.
- Mini Mental State Examination (MMSE) score below 24.

Reliability Testing Methodology

Objective:	Test the consistency and accuracy of the device
Participants	196 healthy individuals (Phase 1), 196 stroke survivors (Phase 2).
Procedure	Glass with sensor placed at various angles on a wooden board. Measured angles compared with a goniometer for accuracy.
Intra-Class Correlation (ICC)	0.98, indicating high reliability. Concurrent validity confirmed through comparison with KINOVEA motion analysis.

Reliability Testing with wooden quadriceps board

Reliability testing with Goniometer Setup

Continued…….

- Wooden quadriceps board which can be positioned in 5 different angles was used.
- Tilt Sensor Device placed over the wooden board in each of these angles
- Goniometric angle measurements taken simultaneously
- Tilt sensor angle values and Goniometric angle measurements are correlated.

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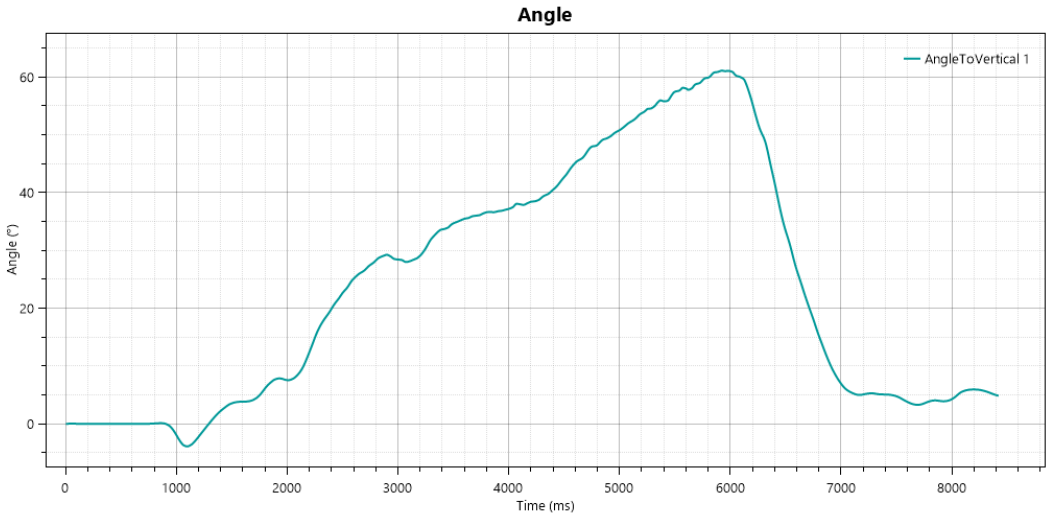
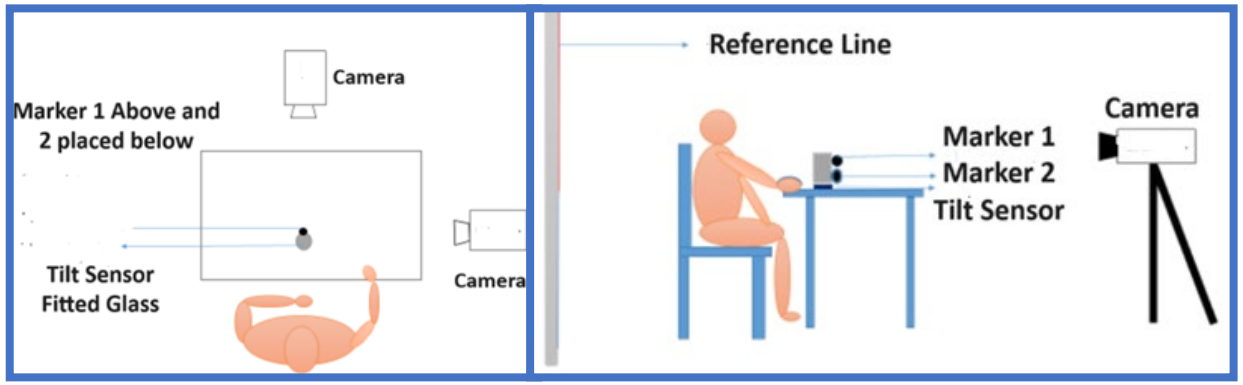

Angle
AngleToVertical 1
60
40
20
0
Angle (°)
0
1000
2000
3000
4000
5000
6000
7000
8000
Time (ms)

Concurrent Validity Testing Setup and Kinovea Motion Analysis



Drinking activity

Motion Analysis with Kinovea Tool

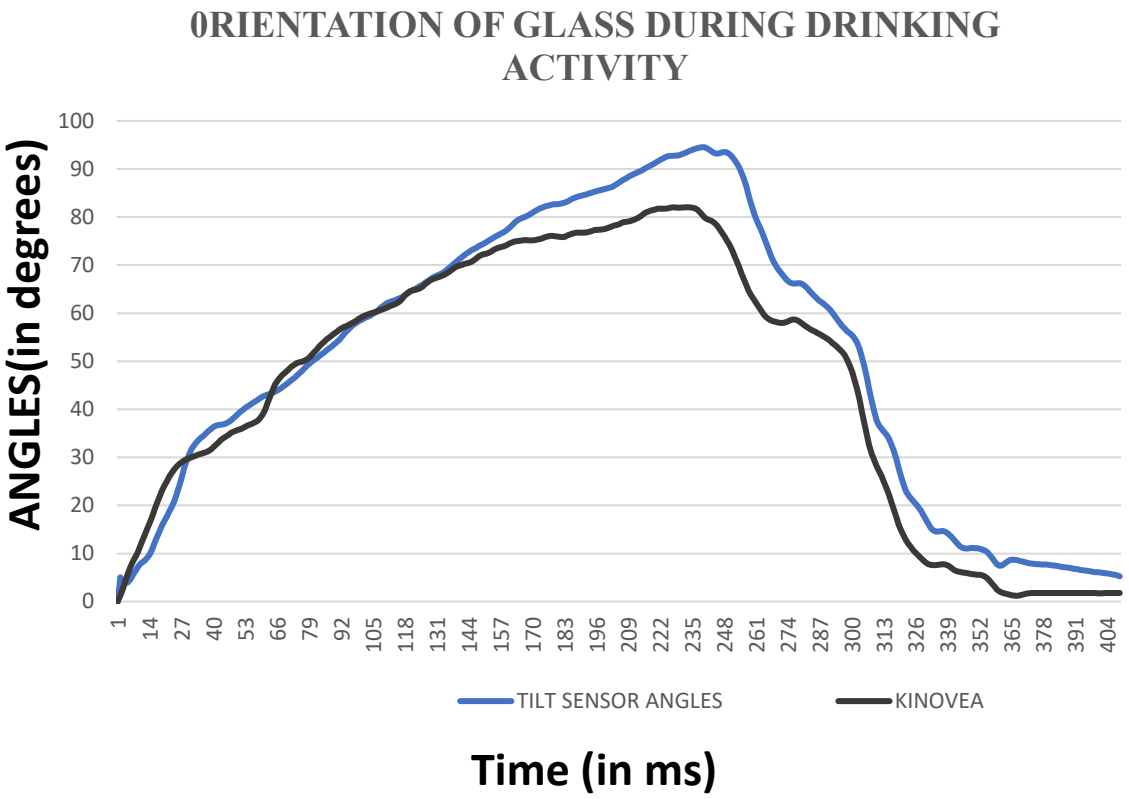
Concurrent Validity Testing

Objective: To compare device output data with motion analysis data from Kinovea software.
Procedure: Glass fitted with the tilt sensor placed on a table in front of participants. Two cameras recorded the drinking task (side and front views).Reference markers on the glass were used to track orientation.

Kinovea Motion Analysis:

Software: Kinovea, a 2D motion analysis tool, used to track the glass tilt.
Validation: Angle of the glass measured using Kinovea is compared with tilt sensor readings. High correlation between Kinovea data and sensor readings validated the device's accuracy.

Data Analysis and Correlation

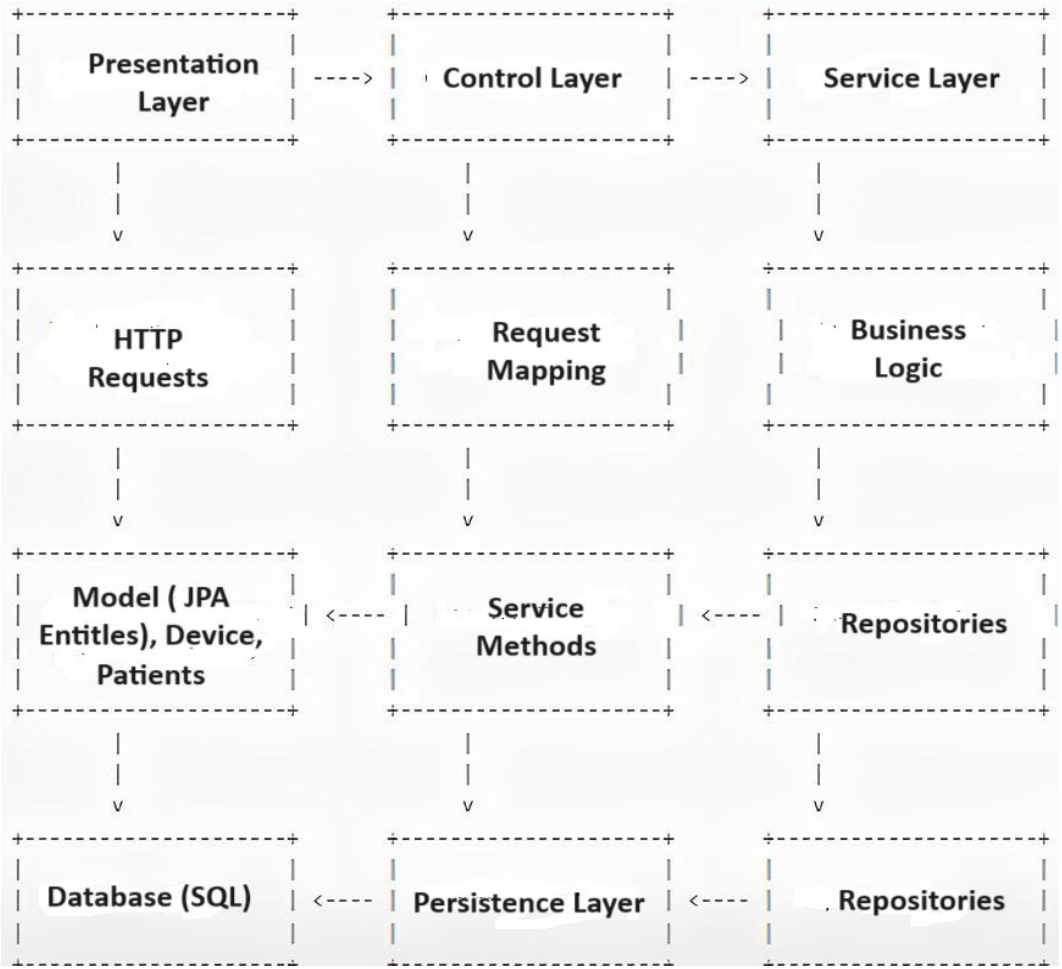


Key Results:

Correlation: Pearson's correlation coefficient of 0.78, indicating a strong agreement between the two datasets.

Reliability: ICC value of 0.99, demonstrating excellent consistency and reliability of the tilt sensor measurements.

AI-Driven App Development



Data Collection: The app analyzes SQL files generated from tilt sensor data during rehabilitation sessions. Machine Learning

Integration: Uses machine learning algorithms to analyze user performance, identifying patterns in tilt data and rehabilitation progress.

Personalized Feedback: Based on the data, the app generates tailored rehabilitation strategies, adjusting over time to improve motor control and function.

Continuous Learning: The app evolves with user input, adapting recommendations to the specific needs and progress of each stroke survivor.

Key Findings and Results

Device Performance

- **High Reliability:**
  Intra-Class Correlation (ICC) of 0.99 in both healthy individuals and stroke survivors, confirming the consistency of the tilt sensor.
- **Accuracy:**
  Significant reduction in orientation error during drinking tasks (from 2.31° without feedback to 0.85° with feedback).

Correlation with Kinovea

- **Strong Agreement:**
  Pearson's correlation coefficient of 0.78 between tilt sensor data and Kinovea motion analysis, demonstrating accurate measurement of tilt angles.

Participant Outcomes

- **Improved Motor Control:**
  Stroke survivors showed improved control over glass orientation, reducing spillage during drinking tasks.

AI-Driven App Insights

- **Personalized Feedback:**
  Real-time, individualized rehabilitation strategies enhanced participants' ability to perform drinking tasks.

Working Video

Project Team

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Thank you!