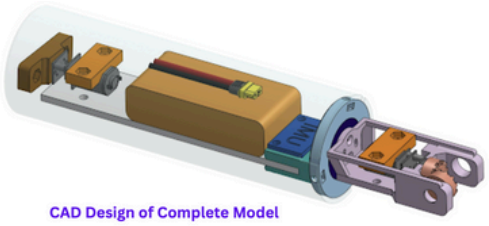
SMART SPOON FOR PARKINSON'S PATIENTS

Technical Team leader | World Robot Olympiad Germany | Jun 2022 - Dec 2023

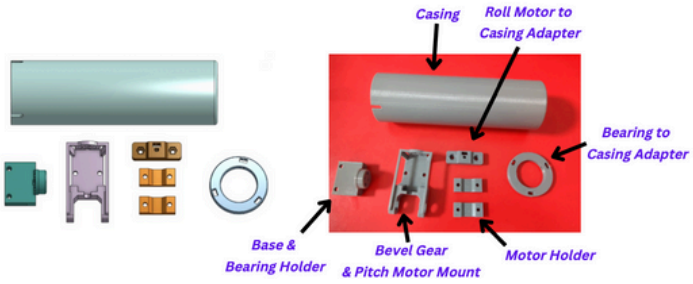
Link to the Youtube video!

CONTEXT

Developed a **compact, intelligent stabilizing spoon** to assist individuals with **Parkinson's disease** who experience **hand tremors** while eating. **Inspired by my uncle** who suffers from PD, our goal was to create an **accessible, affordable and effective mechatronic assistive device** to improve the quality of life through **robotics in healthcare.**



CAD Design of Complete Model



GOALS

- Design an **ergonomic** and compact spoon that compensates involuntary hand tremors.
- Use **IMU data** and motor feedback to stabilize the spoon in real time.
- Develop a **responsive PID control system** to counteract pitch and roll axis of the spoon.
- Optimize the system for low to mid frequency tremors. **(2 - 7Hz)**
- Ensure cost effectiveness and accessibility for the Indian healthcare market.

TECHNOLOGIES USED

- CAD & Prototyping: Onshape, 3D Printing
- Microcontroller: Arduino Nano (**C++** via Arduino IDE)
- Sensors & Actuators: **MPU9250 IMU**, N20 Gear Motors with Encoder, **Kalman filter** for sensor fusion
- Control Systems: Self tuned PID algorithm, PWM motor driver
- Electronics: DRV8833 Motor Driver, Boost Converter, LiPo Battery
- System Design: Embedded programming, hardware interrupt based motor feedback, **iterative testing**

CONTRIBUTIONS

As the technical team lead, I was responsible for **research and development** of this product

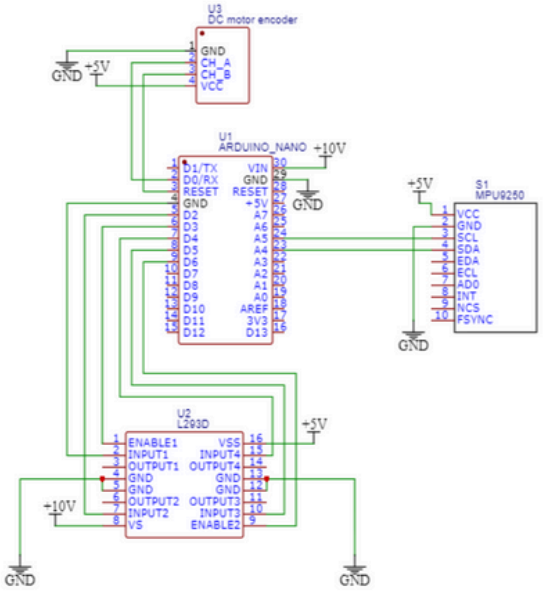
Mechanical Design:

- Created the full 3D CAD of the smart spoon using Onshape.
- Designed compact housings for motors, bearings and IMU.
- Iterated across multiple prototypes (60mm -> 40mm casing), balancing **ergonomics** and internal volume.

Electronics & Soldering:

- Designed the **circuit architecture** and hand soldered the full electronic system, including the IMU, motor drivers, DC-DC converters, LiPo power delivery.

Circuit Diagram



Control System Development:

- Tuned a **custom PID controller** for two axes of motion using real time IMU feedback.
- Made sure this tuned PID controller works well for low to medium frequency hand tremors and with the weight of food on the spoon
- Integrated motor encoder readings via hardware interrupts for **precise positioning**.

Microcontroller Programming:

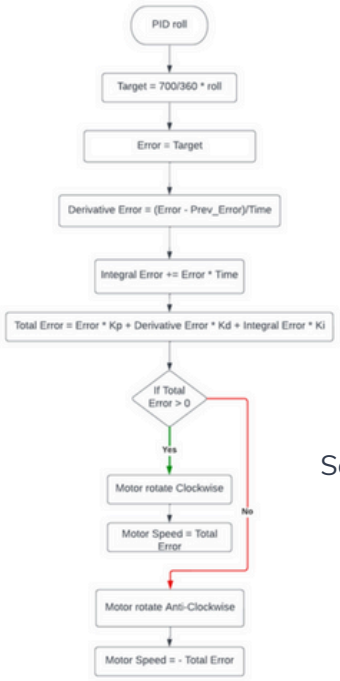
- Programmed the Arduino Nano in **C++**, implementing logic to stabilize the spoon based on roll and pitch angle values.
- Added **logic** to pause motion when the user is picking up food.

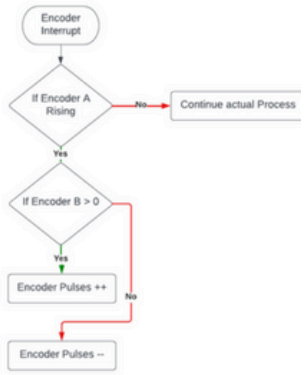
Iterative Testing & Redesign:

- Switched from MPU6050 to MPU9250 to improve angular range and use the magnetometer.
- Switched from using the Pro Mini to Nano for better reliability and easier integration
- Replaced **FDM printed gears with SLA printed** and LEGO based alternatives for less backlash and durability.

Real world Testing & Validation:

- Performed system validation with Parkinson's patients via collaboration with RV College of Physiotherapy. Made technical improvements based on medical expert and patient trial feedback.





Software logic flowchart

Validation trial of the Smart Spoon

RESULTS

- Successfully stabilized spoon's pitch and roll, **reducing tremor transfer by ~70% in testing.**
- **Spoon's responsiveness** was proved sufficient for low and medium frequency tremors by patient trials and testing.
- Recognized by neurologists and designers from **Dozee, Dynocardia, and Max Planck Institute** for the immense real world impact.
- Medical publication is in progress and planned startup collaborations for manufacturing.

Me presenting the Smart Spoon at WRO Germany to judges and Med-tech experts

Aarav Anil *has represented India in over 20 robotics competitions held in the US, Russia, France and other countries. The* **TOI** *#Unstoppable21 jury has picked the teenager from Karnataka as one of the* **Unstoppable 21 Indians under 21 years**

Bengaluru teen builds smart spoon for Parkinson's patients

Aarav Anil was searching for ways to make life a little easier for his uncle who has Parkinson's, so he built a battery-operated smart spoon that would let a patient feed themselves more independently. His prototype bagged first place in a robotics competition held in Germany last November where the 17-year-old represented India.

"One of the symptoms of Parkinson's disease is hand tremors that make it difficult to do basic things like buttoning a shirt or feeding yourself. My uncle's hands used to shake so much that by the time the spoon reached his mouth, most of the food would spill over. I made the spoon using a 3D printer and sensor motors. The spoon compensates for his hand tremors and maintains stability," Aarav said.

Earlier this year, he tied up with RV College of Physiotherapy in Bengaluru to validate the product and gather feedback so it can be made consumer-friendly before mass production begins.

"Working on the feedback that the spoon was rather bulky, I tweaked the design to make it easier to grip and sent it back for trials. I also improved sensitivity to make it more responsive to higher frequencies," Aarav said.

A student of class 12 at Presidency School in Bengaluru South, Aarav has represented India in over 20 robotic competitions held in the US, Russia, France and other countries.

His fascination with robotics started at the age of nine when his mother gifted him a Lego kit that he just couldn't stop playing with. "The combination of mechanics, software and electronics absolutely captivated my

platform," he said.

When he is not working on products to change the world for the better, Aarav is busy using his skills to upgrade his room. "I like to build stuff for myself, there is a lot of trial and error involved but there is so much to be learned from failures as well. It was very hot in Bengaluru this year, so I built a fan with speed controls, and lights with automatic brightness adjustment for my room."

With just a few months left to start applying to colleges, he wants to pursue a degree in robotics and engineering in the Netherlands.

"When I visited the country for a competition, I found that they have good courses that are practical-oriented. Engineering courses in India are very theory-oriented, and very stressful to get into. I don't like slogging up just to write

#Unstoppable21

Beginning August 15 this year, TOI began a hunt to identify and celebrate 21 of India's young prodigies, under 21. To know more about those selected by a jury of eminent personalities and making their mark in the world, visit www.unstoppable21.in

ROBOTICS ACE: Aarav's prototype bagged first place in a robotics competition in Germany last year

job and started an institute called Robolectro Team Studio to provide other children with a platform to learn such 21st-century skills six years ago."

His father is a mechanical engineer and Aarav's work as a mechatronics engineer comprises the best of both worlds. But whenever he hits a wall while work-

Aarav's fascination with robotics started at the age of nine when his mother gifted him a Lego kit. "The combination of mechanics, software and electronics absolutely captivated my interest. Looking at how I was inspired by robotics, my mother quit her job and started an institute called Robolectro Team Studio to provide other children with a platform to learn such 21st-century skills six years ago," he said.

ing on his projects, he turns to YouTube. "Apart from my school teachers, it has

The Guardian

Int

Indian schoolboy invents affordable smart spoon for trembling hands

A 17-year-old with a passion for robotics has produced a cheaper utensil that uses sensors to cancel out hand tremors

The smart spoon for people with tremors is undergoing trials at the RV College of Physiotherapy in Bengaluru, India. Photograph: Courtesy of Aarav Anil

Aarav Anil and the smart spoon he invented for those with Parkinson's disease. Photograph: Zegatta/Courtesy of Aarav Anil

anything upwards most Indians. He