

# ROBOLECTRO KINESIST



## SMART SPOON FOR PARKINSON'S PATIENTS

IMPROVING LIVES TOGETHER



### TEAM MEMBERS

AARRAV ANIL

ARYAN PATWARI

NISHYANTH KUMAR

### COACHES

VIDHYASAGAR G M

ASHWINI ANIL



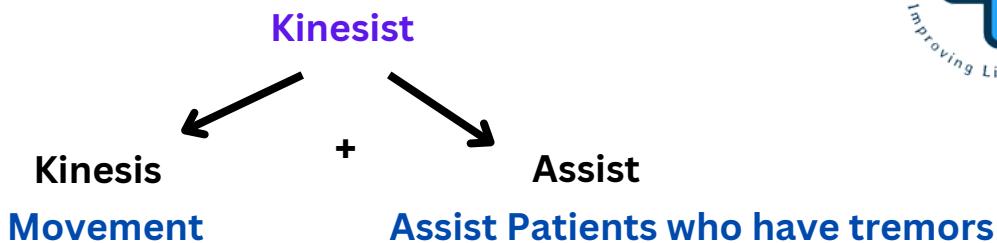
TEAM INDIA

WRO FUTURE INNOVATORS 2022

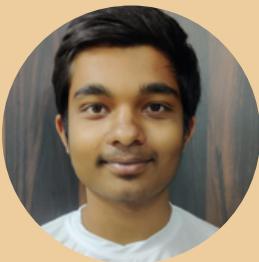




# Our Team - RoboLectro Kinesist

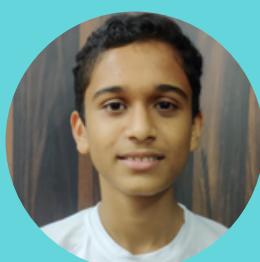


## Team Structure:



**AARRAV ANIL**  
**Mechatronics - Design and Development**

- Into Robotics since 10 years
- Won a total of 15 awards in WRO, FLL, Robocup and Robofest.
- Have represented India in International Level FGC, Robocup, CoSpace and Robofest competitions.
- Certified SolidWorks Associate for CAD Design from Dassault Systemes.
- Loves to design and develop his own creations - CAD Design, 3D print and add electronics
- YouTube channel - **Aarravoltics**



**ARYAN PATWARI**  
**Software - Design and Development**

- Into Robotics since 5 years
- Won numerous awards in **FLL**
- Very creative and loves to edit videos
- Loves to explore new stuff and build hands-on
- Ardent **football** player



**NISHYANTH KUMAR**  
**Research, Outreach and Medical Guru**

- Into Robotics since 4 years
- Participated in FLL
- **Moderator of MIT App Inventor Global Community**
- **Space & Aeroplanes** are his passion
- Loves to play the piano



**Vidhyasagar Govinda swamy Mangai**  
**Coach - Mechatronics Engineer**

- Innovative and Thinks out-of-the-box
- Passionate about Coding
- Loves to teach and inspire children



**Ashwini Anil**  
**Coach - Engineer turned STEM Educator**

- LEGO Robotics Certified Trainer, CMU, USA
- Passionate about Robotics and Teach kids using the STEM based approach
- Mentor kids to solve real-world problems through out-of-the-box thinking and develop skills necessary to excel in the 21st century

**We are a team who love to give back to the community using innovative solutions**

Hello, uncle

Hello.  
What brings  
you here?

I wanted to  
check on your  
health.

My Parkinson's is  
getting worse. The  
tremors in my hand  
have increased and I  
am not able to eat  
properly

I wish there was a  
device that would  
help me eat  
better.

And so, we set off to do  
exactly that.



## RoboLectro Kinesist: A Smart Spoon for Parkinson's Patients

Artificially Intelligent  
Electronic Stabilizing device

Specially designed for Patients  
who have low to mid level  
tremors

Compact  
and  
Easy to Use



Worry less  
about Spilling



Enjoy your  
meal

# Our Research - Outreach with Experts

Our motto of "Improving Lives Together" made us to choose Robots in Healthcare. We wanted to make sure our idea to help PD patients was improving lives. We also were interested to know about the problems faced in the healthcare domain.

The discussions with the following experts guided us the right direction

## Dr. Kishore, Neurologist Aster RV Hospital, Bangalore

### His feedback on Smart Spoon:

- Very helpful for patients with low to mid level tremors
- Not just for PD patients, the smart spoon can be used for patients with essential tremors.
- Can be enhanced to add attachments like cup and fork



## Mr.Gokul Rajamanickam, Systems Architect, Dynocardia, MA, USA

### Thoughts on helping PD patients:

- Helping Parkinson's patients is a good thought
- Stabilization mechanism is better than a device which will send reports to the doctor.
- Should be cost effective for the Indian Market

### Other ideas:

- Surgery robots, Assistive robots, drug delivery robots, navigation within home robots

## Ms.Pooja Kadambi, Head of Innovations, Dozee, Bangalore

### Thoughts on helping PD patients:

- Tremors in PD patients are not constant
- Controlling the movement using gloves for PD patients will cause pain. Instead, better to go with **Correcting Impediment**

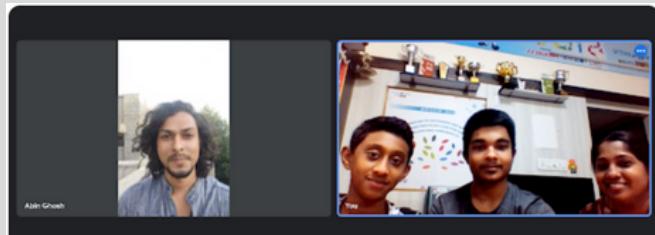
### Other ideas:

- Walking stick for emergency support
- Wearable sensor to detect preemptive stroke
- Fall detection Device + Robohelper

## Ms.Priyanka, Bioinformatics Scientist, Wave Life Sciences, USA

### Ideas:

- Wearable devices for patient monitoring
- Robots to help in drug discovery
- Send reports of PD patients through remote monitoring



## Mr. Abin Ghosh, Designer of wearables for PD patients, Dozee, Bangalore

### Thoughts on helping PD patients:

- Stabilization spoon - dampen out higher frequency
- Can use reaction wheels but not with large motors which will be cumbersome for the patients to hold
- Stabilization similar to Drones can be checked

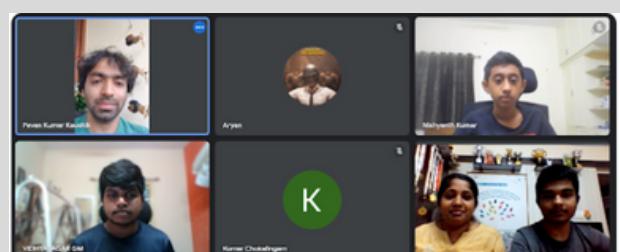
### Other ideas:

- Automated sending of PD report to doctors

## Dr. Pavan, Max Plank, Germany

### Thoughts on helping PD patients:

- Making a compact spoon is a challenge
- Design can be similar to a phone stabilizer or a gimbal in a drone
- Make sure to have the prototype tested on PD patients



# Our Research - Ideas that we Investigated

## Controlling the movement of PD patients using gloves

### Pros:

- Helpful for PD patients in hand tremors
- Wearable & Compact

### Cons:

- Most PD patients are old and already in pain. Controlling their movement will cause more pain



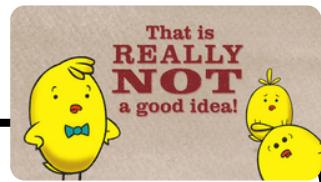
## Fall detection Device + Robohelper

### Pros:

- Very useful for all old people, especially those who live alone
- Most deaths in old age happen because of falls
- When a person falls, the Robohelper navigates to the person to help

### Cons:

- Very tough to test. Need a person to fall each time 😊
- Very challenging to give a demo
- Fall detection App already present in Apple Watch. So, not innovative
- If the person falls in the bathroom, robohelper cannot navigate



## Self Stabilizing Spoon to help Parkinson's patient eat food easily

### Pros:

- Electronically self stabilizes the spoon
- Shakes less than the PD patient's hand.
- PD patients need not worry about spilling and can focus on enjoying their meal.
- Compact
- Low Cost

### Cons:

- Not good enough for high frequency tremor patients
- A little noisy



## Our Research - Existing Solutions and how Different is Ours

Liftware Steady



\$195 for starter kit

GYENNO Spoon



\$199

**Design:** To stabilize the utensil, the computer directs two motors in the handle to move the utensil attachment in the opposite direction of any detected tremor.

Weighted Utensils



**Design:**

This spoon uses ergonomic features and weight distribution with support grip handles to offset hand tremors.

Ranges from \$22.85 to \$45

Self-Stabilizing Spoon For Parkinson's Sufferers  
(Youtube Channel: Barquincs)



**Design:** Uses 2 Servo motors

### How Different is our RoboLectro Kinesist - Smart Spoon

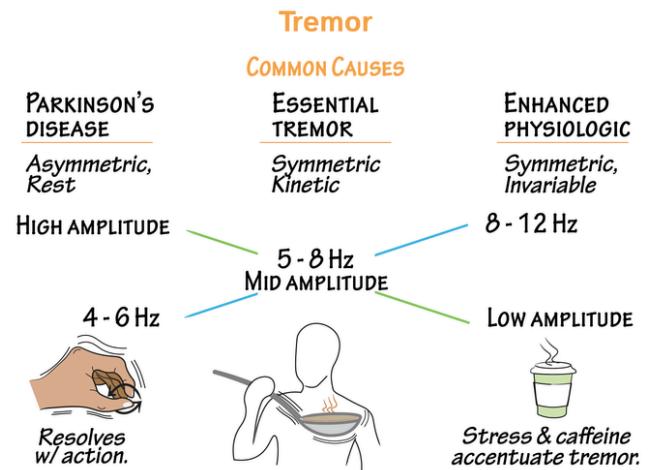
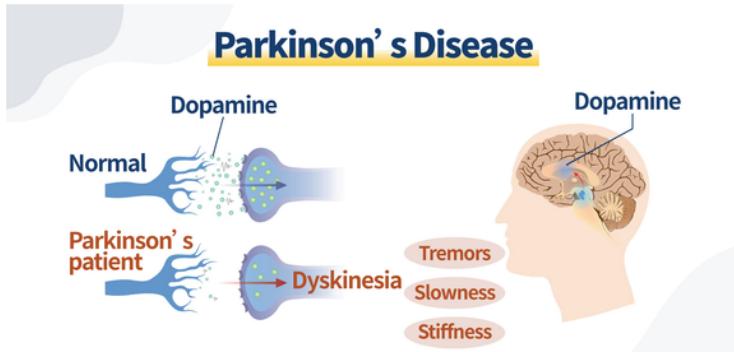
1. **PID controller** - Intelligently controls the motor to rotate in opposite direction of the tremor
2. **Brushed motor with gearbox and Encoder** - highly responsive than the servo motors
3. **IMU (Inertial Measurement Unit)** - 9 degrees of freedom makes the smart spoon more sensitive to tremors
4. **Robust and Stable Design** - All the sensors and motors are stationary to each other
5. **Customized 3D printed components** - Easier to enhance between prototypes
6. **Specially designed** for PD Patients with low to mid level tremors
7. **Compact and Easy to hold** Design

*Overall Estimated Cost of Prototype: Rs. 4000 (~Euros 50)*

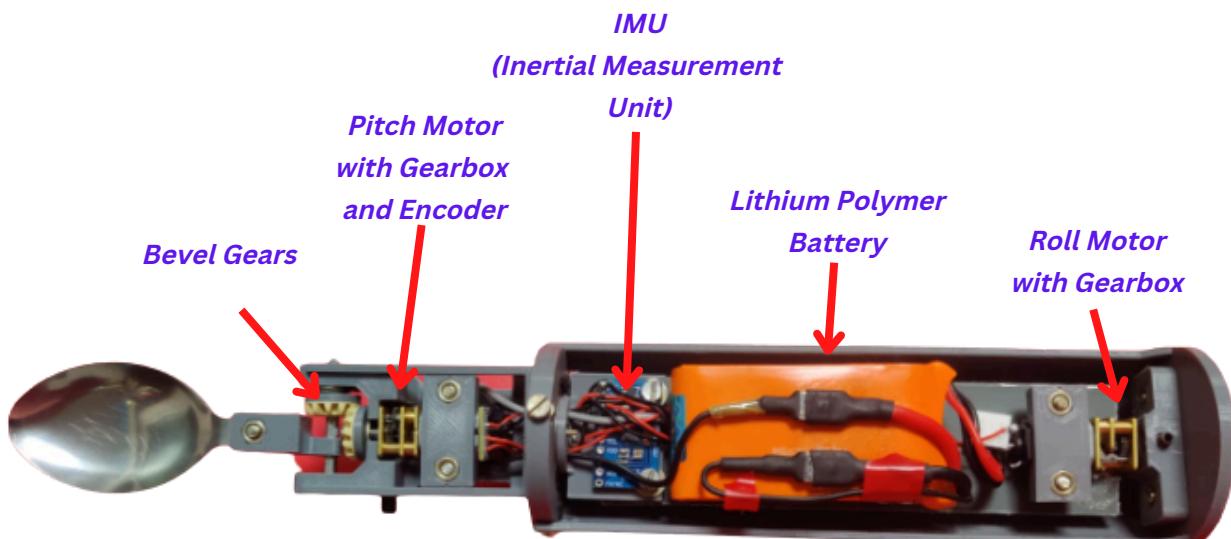
# Design of RoboLectro Kinesist : Smart Spoon

## What is Parkinson's Disease?

Parkinson's disease is a progressive disorder that affects the nervous system and the parts of the body controlled by the nerves.

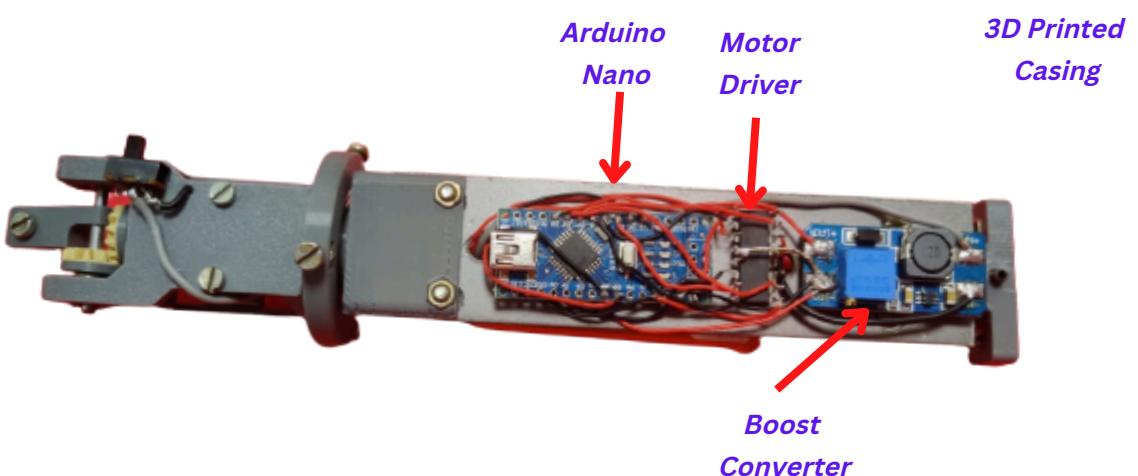


## RoboLectro Kinesist - Smart Spoon for PD Patients



Grey colored Parts

are all  
3D Printed



# Mechanical Design

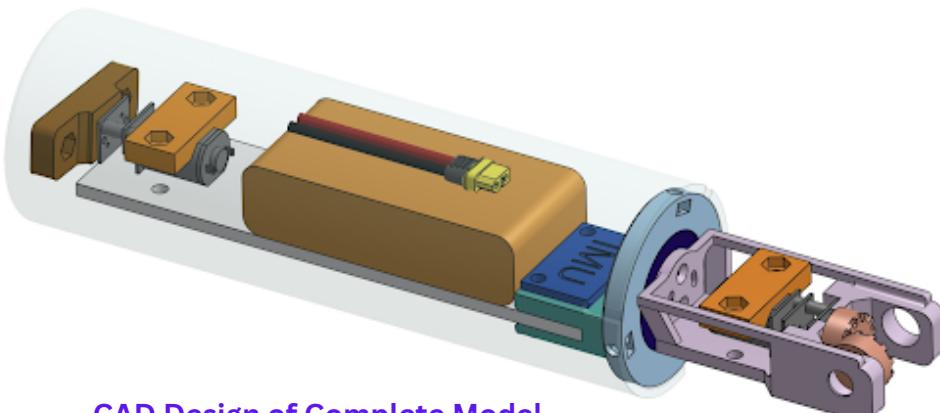


## Mechanical Design Details

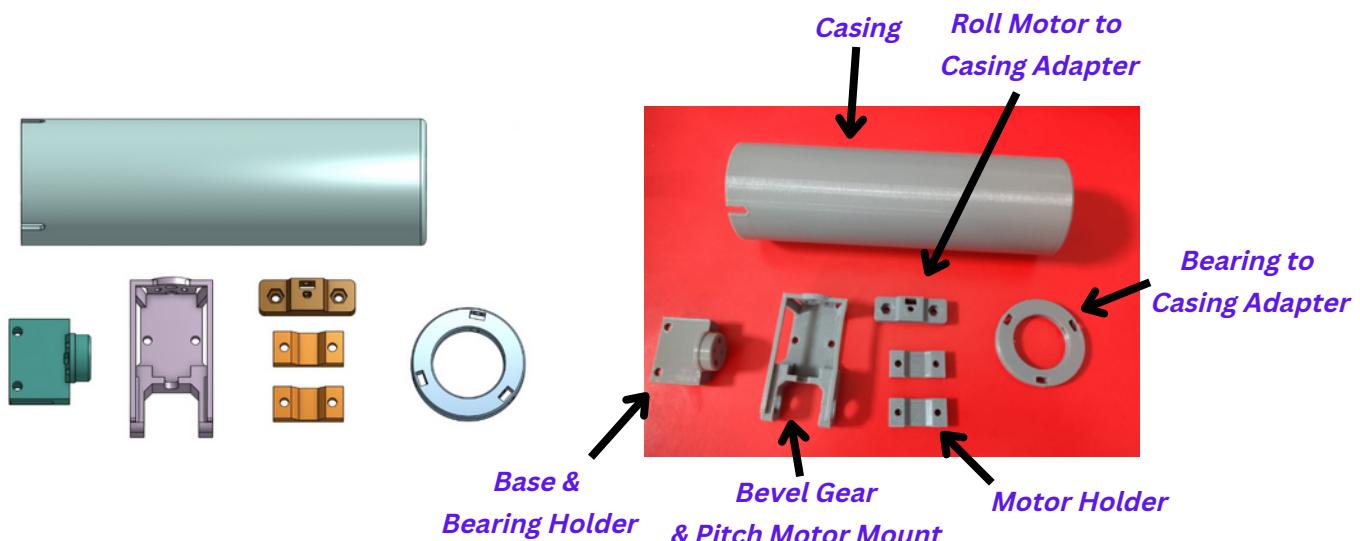
Sl. No.	Requirement	Design Details
1	Easy to Prototype Strong but lightweight Faster Design & Cost Effective	CAD & 3D Printing
2	Less Backlash	Switched from FDM printed gears to SLA printed gears
3	Reduce friction for Roll	Used Bearings for smooth movement
4	Wire Management	All Electronics components and motors are stationary relative to each other. Wires pass through inner diameter of the bearing
5	Easy to access electronics placed inside	Embedded nuts and screws to disassemble the outer casing easily
6	Should not heat up fast	ACP (Aluminum Composite Panels) are used for Heat Management
7	Easy to remove battery for charging	Used FLL Velcro Dual lock sticker to attach the battery to the base
8	Detachable spoon	Used a Wingnut to hold the spoon

## CAD Design of the Final Prototype of Smart Spoon:

We used **OnShape** to Design the mechanical parts of the Smart Spoon. Onshape is a cloud based CAD software which helps working as a team. Created all the assemblies, tested to make sure every component fits in and the 3D printed them.



CAD Design of Complete Model



# Electronics Design



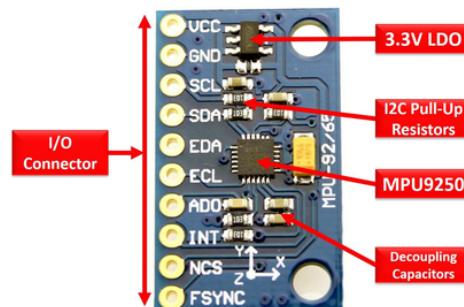
## Electronic Design Details

Sl. No.	Requirement	Design
1	Obtain the Roll and Pitch angle of the tremor	Used the IMU (Inertial Measurement Unit) to measure the roll and pitch angle
2	Obtain the frequency of the tremor	IMU
3	Based on the values, rotate at the opposite direction	Coupled 2 motors: 1. Pitch Motor with Encoder 2. Roll Motor with Gearbox 3. Motor Driver
4	Power to the Smart Spoon	Lithium Polymer Battery
5	Microcontroller to control all components	Arduino Nano
6	To step up to a suitable voltage as per the motor's specification	Boost Converter
7	Indicator to show when battery is discharged	LED

## Component Details:

### IMU (Inertial Measurement Unit) - MPU9250

MPU9250 uses Madgwick Orientation Filter which calculates two angles one from accelerometer, one from gyroscope and uses magnetometer as a correction factor. It combines all these together to obtain much accurate roll pitch and yaw angles. IMU is placed in the center of gravity of the spoon



### N20 Gear Motor with Encoder



Has a 100:1 speed reduction gear mechanism  
Encoder is useful for positioning of the motor shaft  
Used for pitch compensation

### N20 Gear Motor without Encoder



Used for roll compensation

### DRV8833 Motor Driver



Drives both the motors using PWM (Pulse Width Modulation)

# Electronics Design Contd



**Orange 850 mAh 2s 7.4V  
Lithium Polymer Battery**

Powers the Smart Spoon



**MT3608  
Boost Converter**

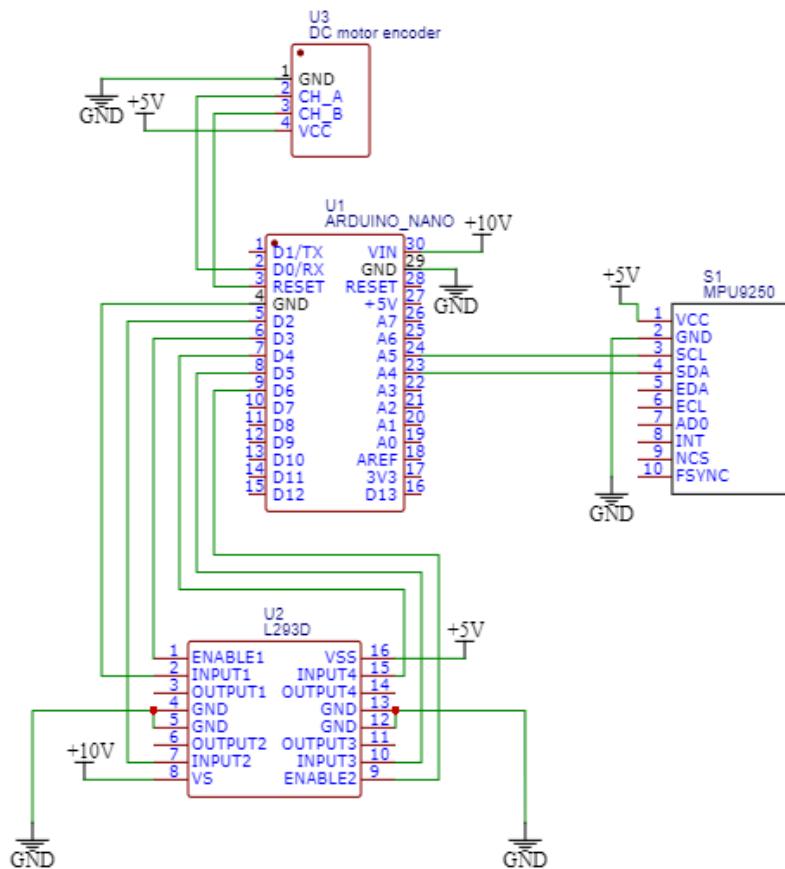
Boost Convertor to Step-Up the voltage required by the motors



**Arduino Nano**

Microcontroller to control all the components

## Circuit Diagram



# Software Design



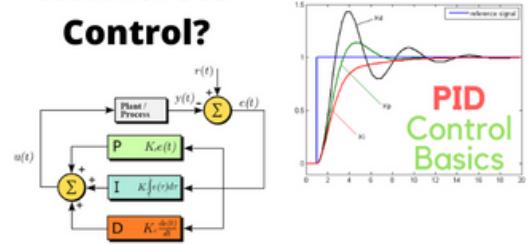
We have used Arduino IDE which uses C++ language to code the logic into the microcontroller.

## Logic:

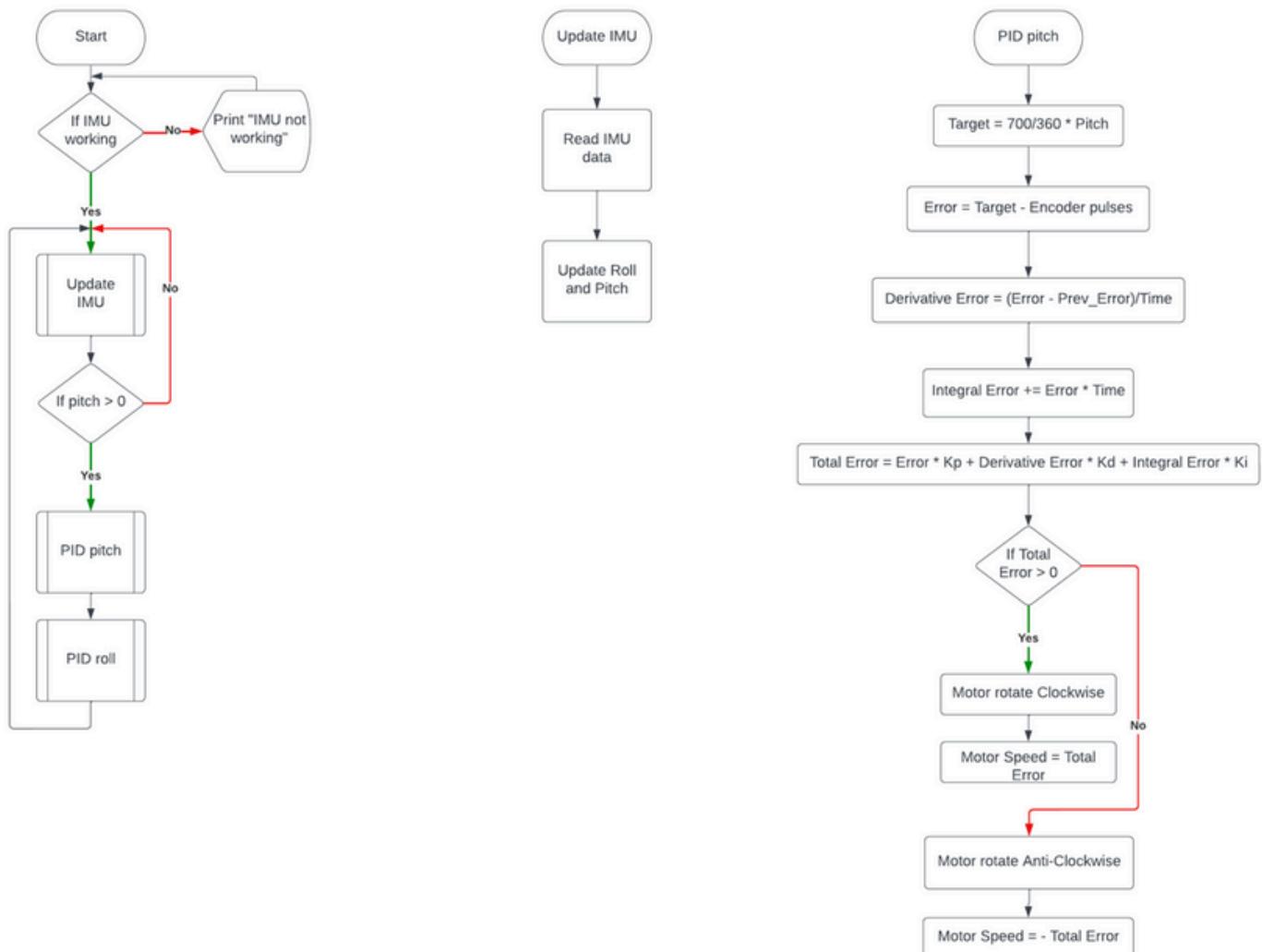
1. Check if the IMU is working. If working, calibrate the IMU sensor.
2. When the IMU starts sensing the tremors, the change in roll and pitch is acquired from the IMU.
3. The values of roll and pitch are passed into the PID function.
4. The PID has been tuned in such a way that it positions the two motors so that the spoon stays parallel to the ground at all times.
5. To measure the position of the motor, we used an interrupt function that counts the number of pulses of the encoder.

[Scan QR code to access the Software in github](#)

## What is PID Control?

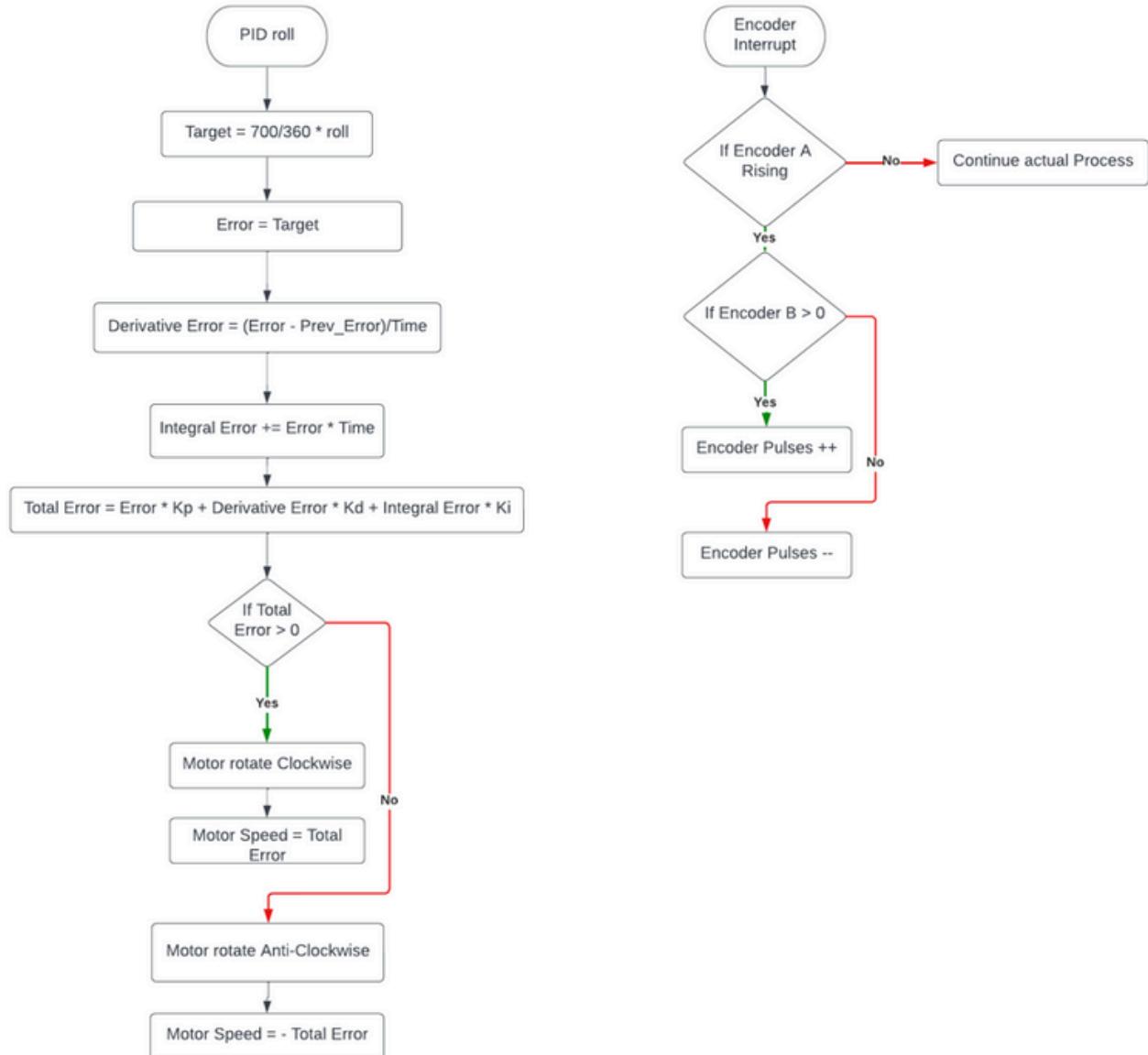


## FlowChart



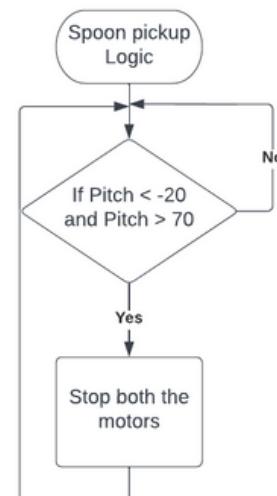
# Software Design Contd.

## FlowChart



We had to include a logic to handle the case of picking up the food (spoon almost parallel to the ground)

If the pitch is  $< -20$  and  $> 70$ , then the motors are stopped so that its easier to pick the food.



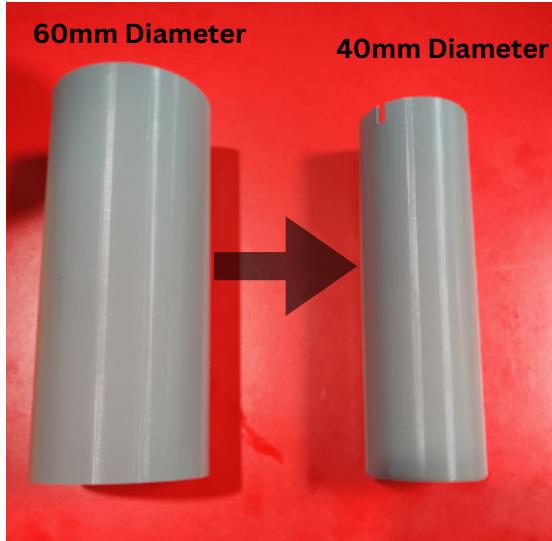
# Challenges faced during development

## Details of all Modifications in Mechanical Design

### Change in Diameter of the casing:

First Prototype had 60 mm diameter outer casing so as to fit all the electronics inside. Chose compact electronic components and reduced the diameter to 40mm

 Compact and Easy-to-Hold Smart Spoon



For each modification,  
We followed  
the  
**Engineering Design  
Process**

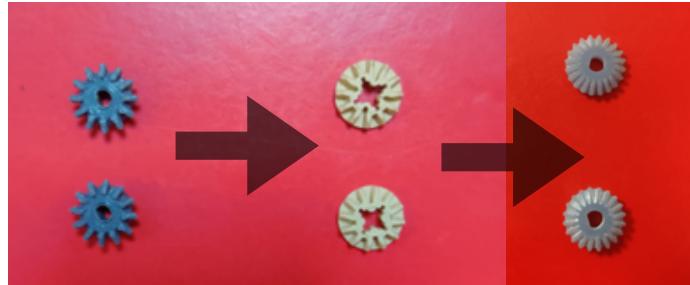
### Change from External Power Supply to Lithium Battery

 To make it compact and wireless



### Changed from 3D Printed Bevel Gears to LEGO Gears to SLA Resin Printed Gears

 To reduce Backlash and friction



### Changed from 3D Printed Spoon to Steel spoon attachment

 To enhance usability, the 3D printed spoon was replaced with a stainless spoon, which is attached to a 3D printed mount



### Added a Bearing

 This reduced the friction for Roll.  
Helped in Tuning the PID Parameters easily



### Heat Management

Motor Driver heats up quickly

 Used Aluminium ACP sheet for heat management and reduce the temperature of the components.

### Tuning of PID

 3D printed a half cylinder to help accessing the electronic components while tuning the PID

# Challenges faced during development

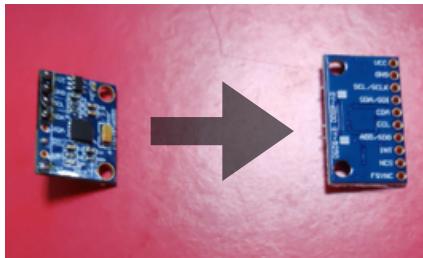
## Details of all Modifications in Electronics Design

### Changed from MPU6050 to MPU9250

MPU6050 could not detect angle > 90 degrees.

MPU9250 measures all 360 degree angle

- ✓ MPU9250 has 3 sensors - gyroscope, accelerometer and magnetometer.
- This increases the range of angle detected.



### Changed from in-built battery connector to spade connector

The connector of the battery was too big to fit inside the model

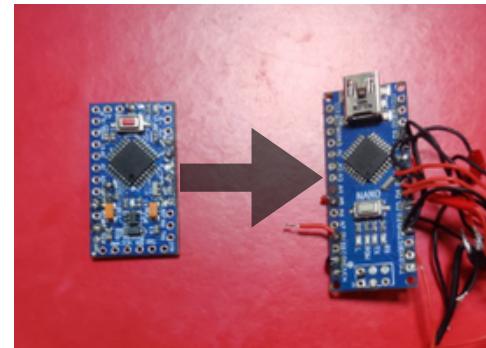
- ✓ Soldered a Spade connector to fit in the casing



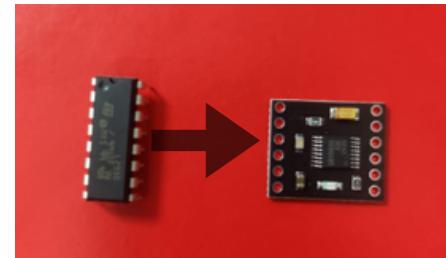
### Changed from Arduino Pro Mini to Arduino Nano

Pro Mini Voltage regulator was not providing sufficient current

- ✓ Arduino Nano works better for our requirements



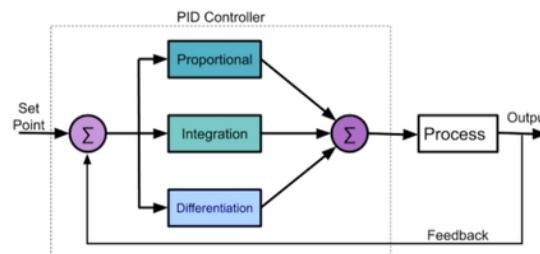
### Changed from L293D to DRV8833 since its more efficient and responsive



## Details of all Modifications in Software Design

### Standard PID to Customized PID

- ✓ Reduced noise caused due to static friction

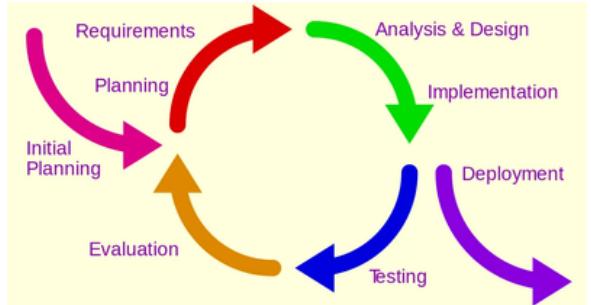


# Testing of Prototype

For each modification in the prototype, we made sure to test the functionalities.

We followed the **Iterative Testing methodology**

As we tested the functionalities, we came across many issues and bugs. To solve this, we brainstormed on the solutions and implemented the changes



(Please refer the Pg 13 and Pg 14 which details on all the problems faced and the design modifications we did)

## Testing in the Real-world

We have collaborated with RV College of Physiotherapy for validating our Smart Spoon with the patients.

Also, we gave a demo of the Smart Spoon to

The smart spoon works well for patients with mid to moderate level hand tremors



**Dr. Kishore, Neurologist  
Aster RV Hospital, Bangalore**



## Future Enhancements

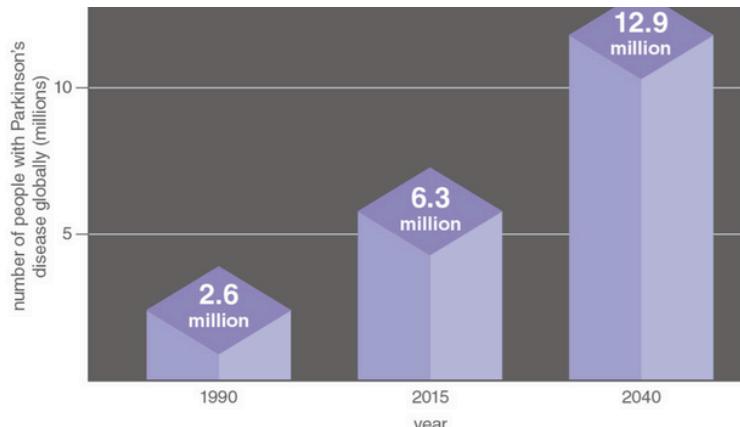
- Add Multiple attachments including fork and cup holder
- Log the tremor details on the cloud and implement Machine learning to easily adapt to the frequency of the patient's tremor
- Share the tremor report to the doctor
- Test on patients who have other kinds of tremors



# Social Impact through RoboLectro Kinesist - Smart Spoon for Parkinson's Patients

Our research started with finding real world healthcare issues.

Since our close family members are suffering from Parkinson's disease, we decided to work on a solution for Parkinson's patients.



*Drastic increase in number of Parkinson's patients over the years*



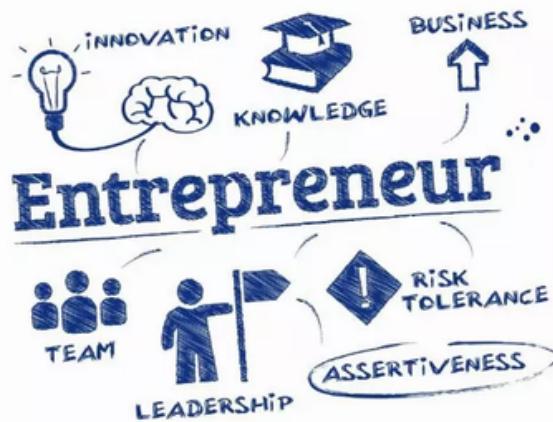
istock

IF YOU CARE for someone with Parkinson's disease psychosis, you know that mealtimes can be some of the most stressful parts of the day. A whopping 80% of PD patients will develop difficulty swallowing, called dysphagia, over the course of their disease—and that makes eating not just frustrating, but possibly dangerous. Moreover, psychosis symptoms like hallucinations can leave PD patients feeling angry, embarrassed, and confused at the table. With a few adjustments in overall PD care, plus some clever dinner-table tools and strategies, meals can be moments of connection,

*Article from HealthCentral.com*

**RoboLectro Kinesist - Smart Spoon**  
is a clever and smart dining table device

# Entrepreneurship



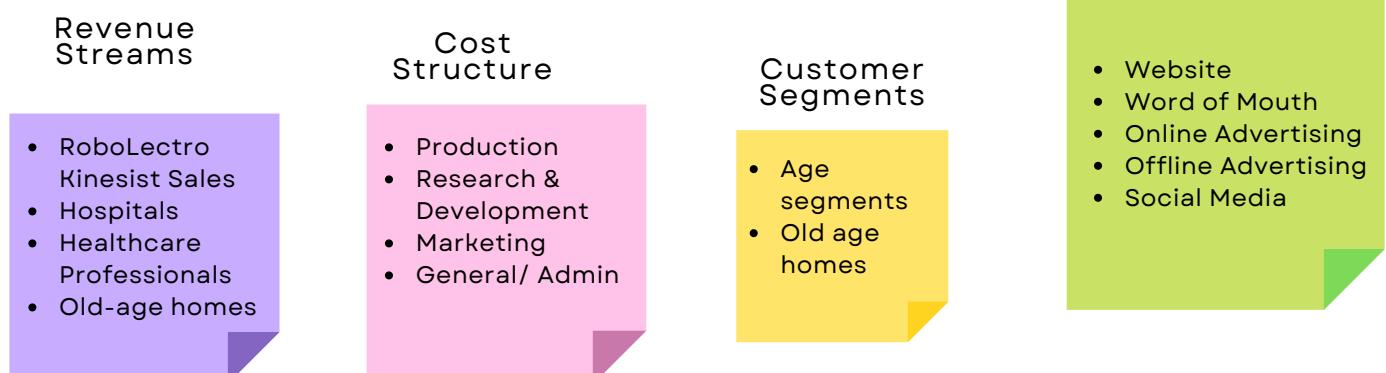
Our plan on starting a start-up:

- Show Demo of our prototype to Medical Device Manufacturers
    - We have scheduled meeting to present our Smart Spoon prototype to the following Medical Device Manufacturer Start-ups:
      - Dozee
      - Dynocardia
      - Comofimedtech
  - Validation of our Prototype with Patients:
    - We have collaborated with R V College of Physiotherapy to conduct the validation on patients. The results of the validation will be published in a Medical Journal soon
  - Production:
    - We have to design and PCB
    - Design the outer casing to have a better look and feel
    - For mass production, 3D printing would not be feasible. We plan to use injection moulding
    - Test the device with patients of varied age group, tremor frequency and other parameters
  - Marketing :
    - Create website and apps for marketing the product
    - Ask doctors/ healthcare professionals in creating awareness of the product
  - **Costing Details:**
  - The cost of Smart Spoon prototype is Rs. 4000 (Euros 50)
    - When the product is manufactured in bulk, the estimated cost should be around
- Rs. 3,000 (Euros 40)**

# Business Model Canvas



## RoboLectro Kinesist Business Model



### Validation of Smart Spoon with patients



Collaboration with  
RV College of Physiotherapy

### Sponsorship



Raised Approximately  
2500 Euros to make  
our Smart Spoon  
a product

## List of Sources

1. Medical and HealthCare Robotics -  
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2. A review of Parkinson's disease - <https://citeseerx.ist.psu.edu/viewdoc/download?doi=10.1.1.504.9141&rep=rep1&type=pdf>
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4. Challenges in Parkinson's disease -  
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6. Parkinson's - movement is medicine - <https://www.youtube.com/watch?v=bD-qLEUArTI>
7. Parkinson's disease - <https://www.nature.com/articles/s41531-022-00331-w>
8. Project : Wearable Robotics For People With Parkinson Disease - Cad Design -  
<https://www.youtube.com/watch?v=Xspc5FqdduY>
9. InMotion® ARM for Neurological Rehabilitation - <https://bioniklabs.com/inmotion-arm/>
10. Robotic Spoon - <https://www.youtube.com/watch?v=te2iQc1TUUm0>
11. Gyroscope Gloves Reduces Hand Tremors For Parkinson's Patients - <https://www.youtube.com/watch?v=eZvvB9WX1Tg>
12. The NeuroMedical Center - <https://www.youtube.com/c/TheNeuromedicalCenterClinicBatonRouge>
13. Stretch with Stretch: Robot-led Physical Therapy for Individuals with Parkinson's Disease -  
<https://www.youtube.com/watch?v=33iy9St0hBw>
14. DIY Arduino Guided Surgical Robot - <https://www.youtube.com/watch?v=oEOupFtSCGo>
15. Wearable Device Detects Stroke in Seconds - <https://aabme.asme.org/posts/wearable-device-detects-stroke-in-seconds#:~:text=A%20medical%20device%20company%20has,detect%20severe%20strokes%20within%20seconds>
16. Active robot-assisted feeding with a general-purpose mobile manipulator: Design, evaluation, and lessons learned - <https://www.sciencedirect.com/science/article/pii/S0921889018307061>
17. DIY Gimbal | Arduino and MPU6050 Tutorial - <https://www.youtube.com/watch?v=UxABxSADZ6U&t=3s>
18. Open Source IMU and ahrs algorithms - <https://x-io.co.uk/open-source-imu-and-ahrs-algorithms/>
19. Using barometers to determine the height for indoor positioning -  
[https://www.researchgate.net/publication/269306407\\_Using\\_barometers\\_to\\_determine\\_the\\_height\\_for\\_indoor\\_positioning#:~:text=A%20barometer%20can%20measure%20the,work%20in%20an%20indoor%20environment](https://www.researchgate.net/publication/269306407_Using_barometers_to_determine_the_height_for_indoor_positioning#:~:text=A%20barometer%20can%20measure%20the,work%20in%20an%20indoor%20environment)
20. Falling Person Detection Using Multisensor Signal Processing -  
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21. 12 Top Technology Devices for Parkinson's To Know About in 2022 -  
<https://www.helloedlife.com/post/6-top-technology-devices-for-parkinson-s-you-should-know-about-in-2021>
22. Self-Stabilizing Spoon For Parkinson's Sufferers - <https://www.youtube.com/watch?v=LCNvCwMxjFk&t=3s>

### Discussion with Experts

1. Dr. Kishore, Epileptologist, Aster RV Hospital, Bangalore
2. Mr.Gokul Rajamanickam, Systems Architect, Dynocardia, MA, USA
3. Ms.Pooja Kadambi, Head of Innovations, Dozee, Bangalore
4. Ms.Priyanka, Biological Market Scientist, Wave Life Sciences, USA
5. Mr. Abin Ghosh, Designer of wearables for PD patients, Dozee, Bangalore
6. Dr. Pavan, Max Plank, Germany
7. Mr. Rakesh Achira, Co-founder, Comofimedtech
8. Dr. Pruthviraj & Dr. Trupti, RV College of Physiotherapy



# ROBOLECTRO KINESIST

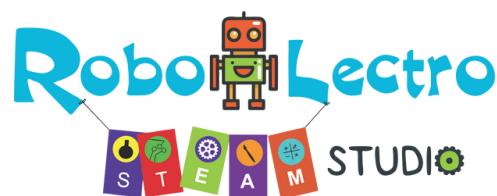
## SMART SPOON FOR PARKINSON'S PATIENTS



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