WINDRAX

Spring 2025 Cohort

DUEN

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Overview

Traditional household fans effectively circulate air, but are dependent on manual user input, such as timers for automatic circulation. Moreover, they are not designed to provide users with cool air, leading to limited effectiveness in reducing room temperature. Through our use of tracking technology and evaporative cooling systems, we've created a fan that doesn't just move with you but also cools with you! WindTrax offers a sustainable approach that lowers users' energy consumption and carbon footprint by using detection sensors to automatically turn the fan on and off based on room occupancy.

Functions:

Tracking mechanism:

- The tracking mechanism within WindTrax is designed to follow the closest person visible by the IMX708 Arducam in collaboration with the Raspberry Pi to rotate and follow individuals within its frame.
- For our tracking mechanism, our computer scientist sourced the You Only Look Once (YOLO) libraries created by Joseph Redmon.

Cooling processes:

- Our cooling processes involve the usage of DURA-COOL, a longer-lasting evaporative cooling pad that is traditionally used in air conditioning (AC) units. By submerging the cooling pad with distilled water and freezing it, WindTrax absorbs incoming heat through evaporation, blowing out cool air throughout the process.

We chose DURA-COOL because:

- Lasts Longer than Aspen Pads (closest competitor for cooling pads)
- No Debris to Clog Pump
- Does Not Decay or Cause Odors
- Designed to be Cleaned and Recycled, therefore better for sustainability

Adaptive behavior:

Unique to WindTrax, our fan will turn off when you leave the room, resulting in saved electricity over time.

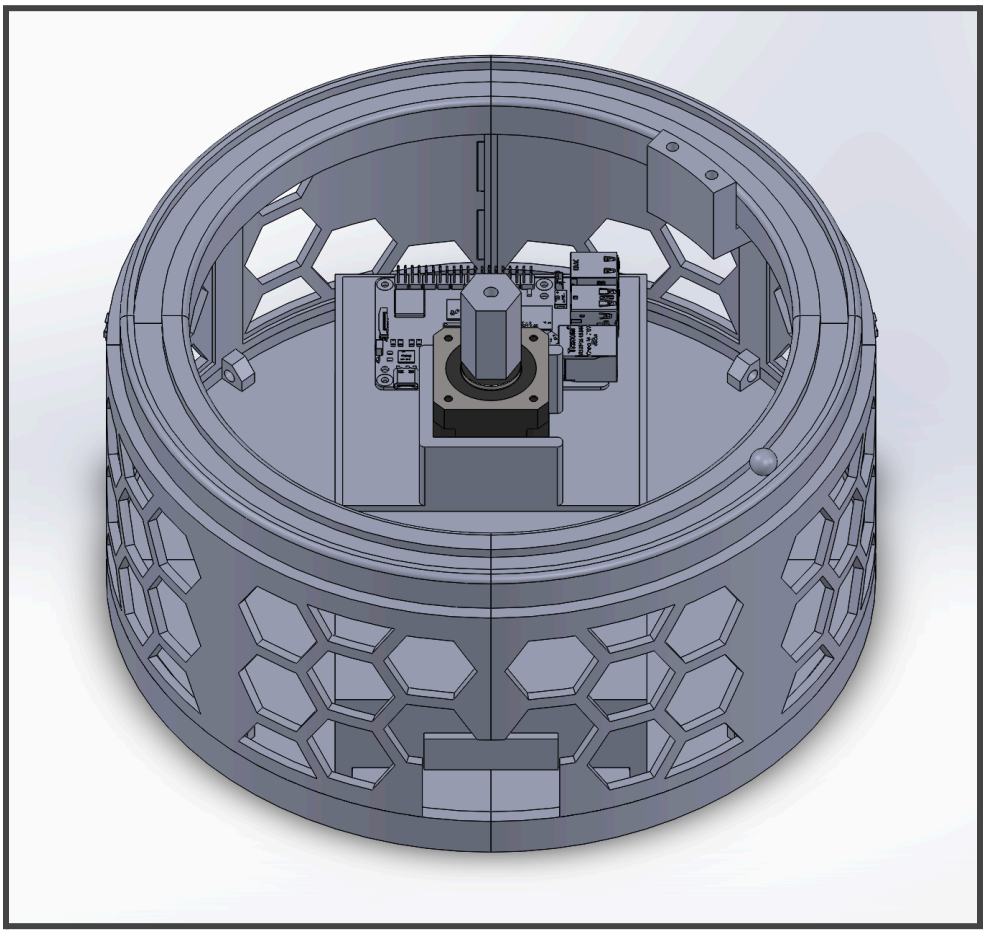

Figure 1: CAD Base of WindTrax

User Guide

Steps To Get Started:

1. Submerge the included blue evaporative cooling pad in distilled water.
2. Place the evaporative cooling pad in the rear panel slot.
3. Snap into place
4. Download the WindTrax App

WindTrax App Guide:

5. Turn Bluetooth ON for your chosen control device
6. Open the WindTrax App
7. Click the blue ‘Scan for Devices’ button
8. Select ‘windtrax’
9. A white pop up will appear with the message ‘Connecting’. Underneath the message click ‘OK’
10. A second dark grey prompt will appear saying ‘Bluetooth Pairing Request’. Click ‘Pair’ to connect WindTrax to your device.
11. A final white prompt will appear signaling a successful connection.
12. Congratulations, you can now turn your fan on, off and adjust the speed.

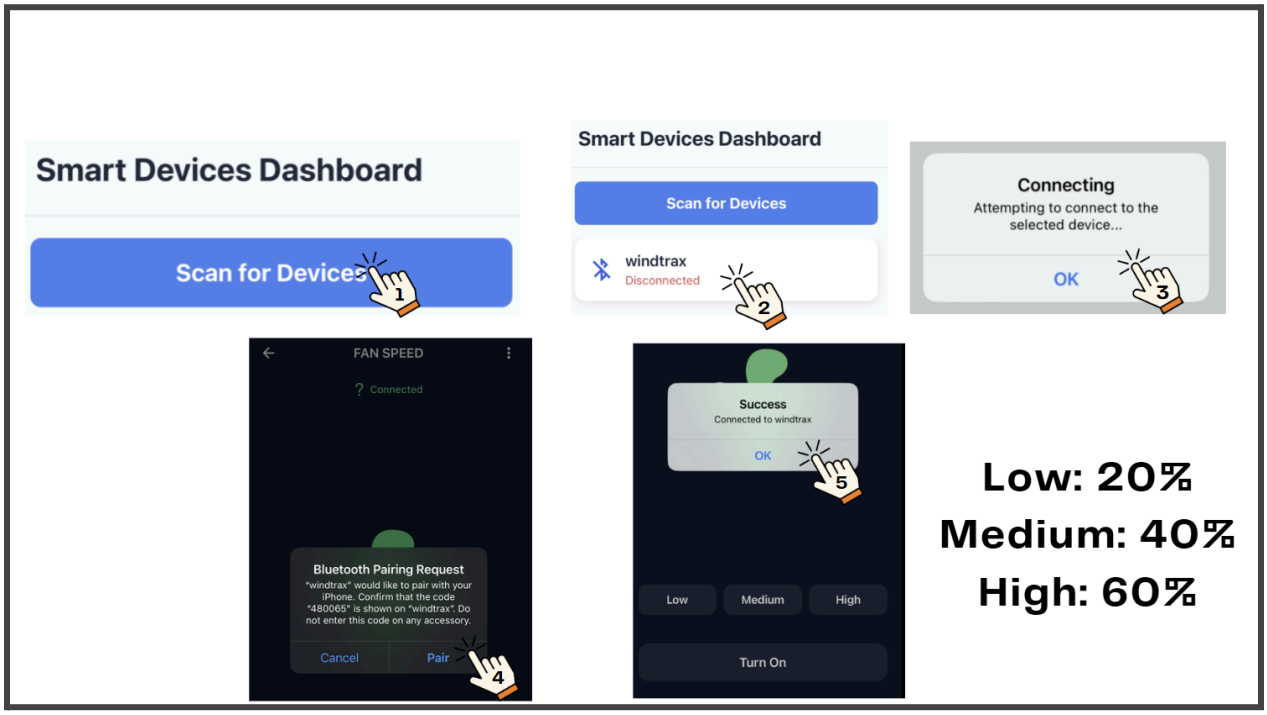

Figure 2: Step-By-Step, How To Connect Your WindTrax Device

Evaporative Cooling Pad Replacement

1. Wet cooling pad with distilled water and wring out lightly.
2. Insert saturated cooling pad into cartridge.
3. Slide cartridge into slot in shroud.
4. After use, remove the cartridge from the rear panel slot.
5. Remove pad from cartridge and fully wring out any excess water.

6. For enhanced results, store extra saturated pads in the freezer before use.

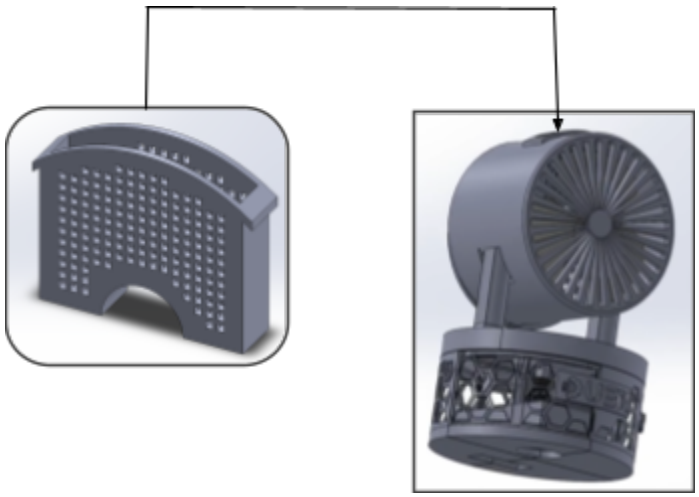

Figure 3: Evaporative Cooling Cartridge Location

How to Properly Power Off your WindTrax Device

1. In the WindTrax app, press the Turn On/Off Button.
2. Manually turn off the power supply at the rear end of the base. Flip the bright red off switch.
3. Unplug the fan out of the wall.
4. Leave the cooling pad out to dry before storing.
5. Store the pad and fan together for future use.

Design/Manufacturing Procedure

Mechanical/Electrical Components

The Windtrax system features a hybrid of innovative cooling and autonomous user tracking, made from modular components and 3D printed PLA parts using black filament. The lower body houses a 775 12V DC motor and a NEMA 17 stepper motor, each mounted securely to custom motor brackets integrated into the body using Computer-Aided Design (CAD). The exterior features an exposed cooling reservoir and translucent side panels to showcase the active airflow system and internal infrastructure.

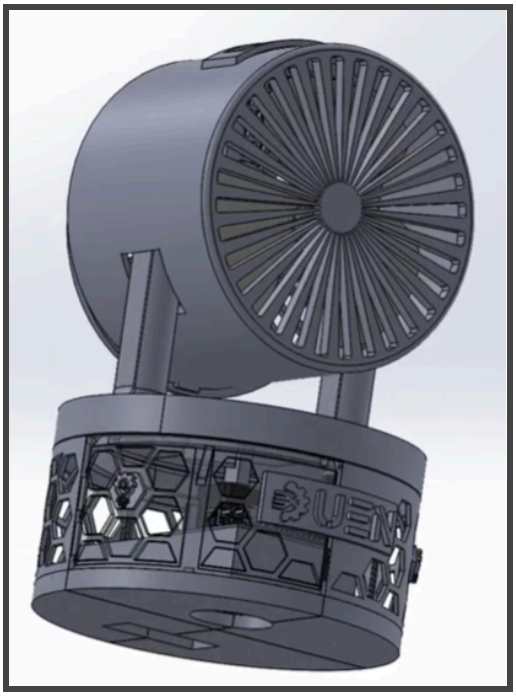

Figure 4: Full CAD Assembly

Evaporative cooling is achieved via the integration of a Dial Dura-Cool Evaporative Cooling Pad, housed in a compartment directly behind the fan intake. The cooling pad is removable and should be submerged in distilled water before use, with airflow directed through it to lower air temperature using phase change principles.

A Raspberry Pi 5 serves as the central processing unit, working together with an Arducam Camera Module 3 mounted on the upper section of the fan. This setup leverages real-time object tracking to detect and follow users. The Raspberry Pi communicates with the motor controllers through a DROK 12V-to-5V buck converter, ensuring safe voltage regulation from a 12V 30A 360W power supply.

The wiring harness uses 10 AWG and 18 AWG stranded wire, with high-current terminals organized using smseace ring connectors for clean crimped terminations. All wiring is routed inside the lower compartment and neatly organized using velcro and zip ties.

Computer Science Components

Aside from acting as the central processing unit, the Windtrax fan uses the Raspberry Pi 5 running Python to control both vision tracking and motor movement. A YOLOv8n object detection model, implemented with the Ultralytics library, identifies people in the camera feed from the Arducam Camera Module 3. When a person is detected, their position relative to the center of the frame determines if and how the fan should rotate.

Stepper motor movement is controlled through the gpiozero library in Python, with GPIO pins connected to a TMC2209 driver. The system continuously tracks motor position to avoid exceeding physical limits and to reset the fan to center if no person is detected for a short period of time. A deadzone is used to prevent unnecessary adjustments when the person is already near the center of the frame.

Challenges and Resolutions

Raspberry Pi 5 Overheating

During initial testing, we encountered consistent overheating issues with the Raspberry Pi 5, especially during prolonged periods of person tracking and motor control. The high processing demand from real-time video analysis using the YOLO model contributed to rapid temperature buildup. To resolve this, we implemented an active cooling solution by adding a heat sink with a miniature fan directly over the Pi's processor. This significantly reduced the temperature increase and ensured system stability during long periods of operation.

Power Supply Instability

During testing, we observed intermittent power issues when both the DC motor and the stepper motor were active simultaneously. At peak load, the motors drew significant current, occasionally causing

voltage drops that led to instability. This was particularly problematic when the fan and tracking mechanisms were engaged at the same time. To resolve this, we upgraded to a 12V 30A power supply capable of handling all system components under full load. We also installed a 6-way fuse box to separate power distribution and improve safety, allowing for easier debugging.

Camera and Tracking Inconsistencies

Another challenge involved the Arducam Camera Module 3 occasionally failing to initialize properly on boot, especially when paired with the Picamera2 library. This caused delays or black frames early in the tracking loop. To address this, we implemented a startup delay and ensured the resolution settings matched the camera's supported formats. Additionally, real-time tracking sometimes misidentified objects or jittered when a person moved near the edge of the frame. To tackle this, our team introduced a deadzone space in the center of the frame to prevent overcorrection and reduce jitter, which stabilized tracking and improved the overall responsiveness of the system.

Maintenance:

- Please use distilled water when soaking the cooling pad to prevent mold
- When not in use for longer periods of time (1-week +), properly dry the cooling pad and place it back into the designated rear panel slot.

Material List and Cost

775 DC Motor 12v	1	775 DC MOTOR	$1.00	$1.00
BTS7960 43A High Power Motor Driver Module	1	BTS7960	$1.79	$1.79
Nema 17 Stepper Motor	2	NEMA17	$3.50	$7.00
5M GT2 Timing Belt	1	TIMING BELT	$1.10	$1.10
DuraCool Evaporative Cooler Pad	1	EVAPORATIVE COOLING PAD	$6.00	$6.00
6 Way 12V Fuse Box	1	12V FUSE BOX	$4.77	$4.77
DC 12V 30A 360W Power Supply	1	12V DC POWER SUPPLY	$15.00	$15.00
Orange Pi Zero 3 1G	1	ORANGE Pi ZERO 3 1G	$15.50	$15.50
Cmos Sensor USB Camera Module Support OEM	1	CMOS SENSOR USB CAMERA MODULE	$4.65	$4.65
TMC2209 Stepper Motor Driver	1	TMC2209	$13.99	$13.99
DROK Buck Converter 12v to 5v, 5A USB Voltage Regulator	1	DROK	$2.85	$2.85
2 ft 10AWG Wire	2	10AWG WIRE	$0.92	$1.84
50 ft 18 AWG Wire	1	18AWG WIRE	$8.99	$8.99
200pcs Ring Terminals 12-Sizes(M3/M4/M5/M6)	1	RING TERMINALS	$6.99	$6.99

Final Reproduction Material Cost: **$73.95**