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Invoice No.: SGI/ANU/START-UP/ AI FAN-PATENT-01/2025

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TUESDAY, NOVEMBER 11, 2025
Our Ref.: **ANU/AI FAN-PATENT-01/2025**

To

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Description	Fee. (INR)
1. Professional fee towards providing general advisory on different intellectual property rights to start ups, providing information on protecting and promoting IPR to start ups in other countries, drafting Complete Specification and preparing and filing other documents such as Form-1, Form-2, Form-3, Form-9 and Form 18A, reporting to client the filing of the Patent Application No. **202531108913** dated 10th **November 2025.**	NIL
2. Government Fee for filing the Patent Application.	INR 15,780/-
3. Miscellaneous expenses including charges for typing, phone, Print outs, photocopy, stamp fee, postal charges, conveyance etc.	INR 1000/-
Total	**INR 16,780.00 (excluding taxes)**
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Sr. No.	App. Number	Ref. No./Application No.	Amount Paid	C.B.R. No.	Form Name	Fee Payment	Remarks
1	202531108913	TEMP/E-1/122116/2025-KOL	5280	13806	FORM 1	Full	AI BASED SMART STANDING FAN
2	E-106/3062/2025/KOL	202531108913	0	-1	FORM28	Full	

TransactionID	Payment Mode	Challan Identification Number	Amount Paid	Head of A/C No
N-0001789871	Online Bank Transfer	1011250044664	5280.00	1475001020000001

Total Amount : ₹ 5280.00
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Sr. No.	App. Number	Ref. No./Application No.	Amount Paid	C.B.R. No.	Form Name	Fee Payment	Remarks
1	E-12/2192/2025/KOL	202531108913	2500	13859	FORM 9	Full	

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N-0001790736	Online Bank Transfer	1111250035144	2500.00	1475001020000001

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Sr. No.	Ref. No./Application No.	App. Number	Amount Paid	C.B.R. No.	Form Name	Fee Payment	Remarks
1	E-3/2204/2025/KOL	202531108913	0	--	FORM 3	Full	ONLINE

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Sr. No.	App. Number	Ref. No./Application No.	Amount Paid	C.B.R. No.	Form Name	Fee Payment	Remarks
1	E20253079630	202531108913	8000	13862	FORM 18A	Full	

TransactionID	Payment Mode	Challan Identification Number	Amount Paid	Head of A/C No
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(57) Abstract :
The present invention discloses an artificial-intelligence-based fan system 100 configured to provide adaptive thermal comfort control and method thereof. The fan system 100 comprises a base unit 102, a mast 104, a privacy-preserving, camera-free sensor suite 106, a controller 108, and an actuation subsystem 110. The base unit 102 configured to accommodate a power-conversion and energy-management module 112 and an energy-storage unit 114. The mast is configured to provide support to a two-axis gimbal head, a privacy-preserving, camera-free sensor suite 106 configured to acquire multimodal data, a controller, and an actuation subsystem 110. The controller comprises a microcontroller unit (MCU) 116 configured to perform real-time sensor fusion, safety monitoring, and motor-control operations, and a neural-processing accelerator 118 configured to execute an on-device artificial-intelligence model. The actuation subsystem comprises the BLDC motor and dual-axis servo drives configured to control blade rotational speed, azimuth oscillation, and tilt angle through closed-loop field-oriented control.

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FORM 2

THE PATENTS ACT, 1970

[39 of 1970]

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COMPLETE SPECIFICATION

(Section 10; Rule 13)

Title of Invention: **AI BASED SMART STANDING FAN**

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The following Specification particularly describes the invention and the manner in which it is to be performed.

FIELD OF THE INVENTION

The present invention relates generally to air-circulation and thermal-comfort devices, and more particularly to an artificial intelligence (AI) based fan system configured to adaptively regulate airflow and comfort parameters in indoor environments through multimodal sensing, real-time control, and local machine-learning inference.

BACKGROUND OF THE INVENTION

Conventional electric fans and air-circulation devices are typically operated using manual switches or basic electronic regulators. Such systems deliver fixed or manually adjusted airflow without consideration of user position, occupancy pattern, ambient conditions, or individual comfort preferences. Although certain premium models employ infrared sensors or timers for limited automation, these mechanisms lack context awareness and are unable to optimize energy use dynamically.

In recent years, Internet-of-Things (IoT)-enabled appliances have incorporated remote control and cloud-based automation features. However, these systems rely heavily on network connectivity and centralized processing, which introduces latency, privacy concerns, and dependence on external infrastructure. Furthermore, cloud-based control architectures are unsuitable for real-time comfort regulation in residential and office settings where fast response and local autonomy are essential.

Existing ceiling fans and tower fans occasionally integrate temperature or humidity sensors for feedback-based operation. Nevertheless, these systems generally respond to a single environmental parameter and do not account for combined factors such as occupancy distribution, air quality, or acoustic comfort. Additionally, known systems lack predictive or learning capabilities to anticipate environmental disturbances (e.g., window drafts, heat sources) or to personalize airflow profiles based on user feedback over time.

Following are the limitations of the prior arts:

1. **Absence of user-centric adaptation:** Existing fans provide uniform airflow and cannot automatically adjust direction, amplitude, or speed according to occupant location or activity.
2. **Lack of multimodal sensing and fusion:** Current solutions rely on a limited number of sensors and do not integrate heterogeneous data such as acoustic, infrared, ultrasonic, and environmental parameters for contextual understanding.
3. **Dependence on external cloud computation:** IoT-based automation solutions often depend on remote servers for inference, causing delays, increased power consumption, and potential privacy violations.
4. **Inability to predict and respond to dynamic disturbances:** Traditional feedback systems lack predictive control models to pre-empt environmental changes such as door openings or temperature fluctuations.
5. **Limited energy and acoustic optimization:** Existing fans do not perform multi-objective optimization balancing comfort, power consumption, and noise.

The invention further provides a method for providing adaptive comfort regulation comprising the steps of acquiring multimodal sensor data, fusing the data to derive occupant vectors, executing perception, comfort-estimation, and predictive-control sub-models on a neural-processing accelerator, generating control signals, actuating the motor and gimbal drives, and updating model parameters based on user feedback and environmental variations.

Therefore, there is a need for an artificial intelligence (AI) based fan system configured to adaptively regulate airflow and comfort parameters in indoor environments through multimodal sensing, real-time control, and local machine-learning inference. The fan system should achieves context-aware comfort control, energy optimization, predictive actuation, and privacy protection within a locally operating embedded system. The fan system should provide dynamic adjustment of airflow direction and magnitude in anticipation of environmental disturbances, self-learning of user comfort profiles, and integration with auxiliary air-circulation devices via secure local communication protocols.

OBJECTS OF THE INVENTION

Accordingly, the present invention seeks to overcome the aforementioned drawbacks by providing:

- An intelligent fan system that performs on-device sensor fusion and AI-driven predictive control to maintain personalized comfort conditions.
- The intelligent fan system configured with a privacy-preserving, camera-free sensing mechanism capable of localizing occupants and estimating comfort levels without image capture or data transmission.
- The intelligent fan system configured with a neural-processing-accelerator-based control architecture configured to execute perception, comfort-estimation, and predictive-control sub-models concurrently in real time.
- The intelligent fan system configured with an Integration of power-conversion, energy-management, and actuation modules that minimize power draw while maintaining smooth, low-noise airflow.
- The intelligent fan system configured with a Capability for self-learning adaptation through reinforcement or bandit learning using occupant feedback, enabling the system to evolve personalized comfort profiles.

SUMMARY OF THE INVENTION

The present invention provides an artificial intelligence (AI) based fan system capable of delivering personalized and energy-efficient thermal comfort through multimodal sensing, real-time sensor fusion, and predictive control using on-device neural processing. The system combines environmental and occupancy sensing**,** adaptive motor control**,** and embedded learning models to autonomously regulate airflow parameters without reliance on cloud connectivity or manual intervention.

The present invention describes a camera-free perception stack that localizes occupants and estimates activity level using a fusion of short-range time-of-flight ranging, ultrasonic echo timing, passive infrared transitions, ambient acoustics, and motor-encoder pose. This multimodal fusion yields a continuously updated “occupant vector” (distance, bearing, relative elevation) and a coarse posture/activity label without capturing images or personally identifiable data. Unlike prior fans that oscillate blindly, the controller infers where airflow is needed, how quickly a person is moving, and how obstacles attenuate the stream, enabling precise steering of the airstream while preserving privacy and operating fully on device with millisecond-scale latency.

Built atop this perception, the invention personalizes thermal comfort through a learned model that fuses temperature, humidity, air speed, and room transients with user feedback signals such as quick tap inputs, schedule context, and passive behavioral cues. Instead of fixed speed steps, a multi-objective optimizer selects fan RPM, oscillation amplitude, phase dwell, and tilt angle to maximize perceived comfort per joule while constraining acoustic emissions. The model adapts across seasons and microclimates, discovers the minimum breeze needed for each user and time of day, and encodes safety envelopes so exploration by the learning agent never violates thermal, mechanical, or ergonomic limits.

A novel phase-shaped oscillation and cone-width modulation strategy coordinates head rotation with rotor acceleration to match the air-jet transit time to the target. The fan briefly narrows its cone and increases exit velocity when spanning distance, then widens and softens the stream near the occupant to avoid buffeting and tonal peaks. By predicting door opens, window drafts, and heat plumes, the controller pre-positions the head and pre-ramps RPM, preventing overshoot and eliminating the lag that characterizes conventional fans. Night profiles synthesize micro-breeze pulses aligned to sleep cycles, lowering average RPM while maintaining perceived coolth.

For multi-occupant spaces, the present invention implements a fairness scheduler that time-divides airflow according to occupant locations, preferences, and comfort deficits. It dynamically shapes cone width, dwell time, and RPM so no user is under-served, even as people enter, leave, or move seats. The scheduler can enforce policies—equal comfort, energy-weighted fairness, or priority for vulnerable users—without manual negotiation, and it exposes discreet haptic prompts for opt-in preference capture. Because localization is camera-free and computed locally, the system supports classrooms, clinics, and shared offices where privacy and low latency are essential.

Safety and self-maintenance are embedded as predictive functions rather than reactive thresholds. A tip-over estimator fuses accelerometer, encoder torque, and base load cell signals to detect instability early and execute controlled spin-down. Finger-approach and foreign-object proximity are inferred using time-of-flight deltas and acoustic signatures, pausing within milliseconds. A motor-thermal digital twin derates torque before overheating, while a vibration/torque-RPM analyzer estimates dust loading, blade imbalance, and bearing wear. The fan issues precise, user-friendly maintenance cues—cleaning needed, balance advisory, filter coordination—based on quantitative degradation rather than crude hour counters.

The invention further distinguishes itself through cooperative building behavior and energy awareness. It integrates with local control protocols to coordinate with ceiling fans, purifiers, or evaporative coolers, preventing counterproductive flows and increasing filter residence time when needed. A tariff-aware mode shifts strategies during peak pricing and rides through brownouts with soft-start and optional battery support, maintaining comfort at reduced power. The architecture is modular—sensor cap, compute board with neural accelerator, BLDC hub, and gimbal drivetrain—

enabling upgrades, recyclable parts, and firmware extensions. Operation is offline-first with optional secure updates; telemetry is anonymized summaries rather than raw streams. Together, these aspects—privacy-preserving perception, personalized multi-objective control, phase-aware airflow shaping, fairness scheduling, predictive safety and maintenance, and cooperative, energy-savvy behavior—constitute a step change from remote-controlled “smart” fans to an autonomous comfort appliance.

An embodiment of the present invention describes an artificial-intelligence-based fan system configured to provide adaptive thermal comfort control. The fan system comprises a base unit configured to accommodate a power-conversion and energy-management module and an energy-storage unit, the power-conversion and energy-management module being configured to supply regulated electrical power to a controller and an actuation system; a mast supporting a two-axis gimbal head comprising a brushless-Direct Current (BLDC) motor, a low-turbulence blade assembly, and acoustic diffusers for low-noise airflow; a privacy-preserving, camera-free sensor suite configured to acquire multimodal data comprising: environmental parameters including temperature, relative humidity, barometric pressure, and air-quality indices; and occupancy parameters including time-of-flight and ultrasonic ranging, passive-infrared transitions, acoustic activity level, and inertial motion, wherein the sensor suite is arranged to generate fused occupant vectors representing distance, bearing, and posture of one or more users without capturing images or personally identifiable data; the controller comprising: a microcontroller unit (MCU) configured to perform real-time sensor fusion, safety monitoring, and motor-control operations; and a neural-processing accelerator configured to execute an on-device artificial-intelligence model including: a perception sub-model trained to infer occupant localization and activity from fused time-of-flight, ultrasonic, acoustic, and motion data; a comfort-estimation sub-model trained through reinforcement or bandit learning to map sensed environmental parameters and user feedback to a personalized comfort index; and a predictive-control sub-model configured to compute optimal actuation parameters by minimizing a multi-objective cost function incorporating comfort deviation, power consumption, and acoustic limits; the actuation subsystem comprising the BLDC motor and dual-axis servo drives configured to control blade rotational speed, azimuth oscillation, and tilt angle through closed-loop field-oriented control; and the controller continuously fuses said multimodal sensor data, executes said sub-models on the neural-processing accelerator, and, based on the predictive-control output, adaptively adjusts fan speed, oscillation amplitude, sweep profile, and tilt angle to maintain a target personalized comfort band with minimum power draw while operating locally without cloud dependence.

According to an embodiment, the controller is configured to anticipate environmental disturbances including door openings, window drafts, or heat plumes by: continuously monitoring acoustic signatures and barometric-pressure variations obtained from the sensor suite; detecting transient patterns corresponding to sudden pressure drops, localized noise bursts, or airflow shifts; predicting a disturbance event through inference by the predictive-control sub-model based on said transient patterns; and pre-positioning the gimbal head and pre-ramping the BLDC motor speed prior to the detected event, whereby airflow direction and magnitude are adjusted in advance to prevent comfort overshoot or airflow lag.

According to another embodiment, the controller comprises a fairness-scheduling module configured to allocate airflow among multiple occupants by: tracking the location and comfort index of each occupant using fused sensor data and the comfort-estimation sub-model; computing a priority or dwell-time weight for each occupant according to a fairness policy; generating an airflow-allocation schedule defining sequential or overlapping airflow cones; and commanding the actuation system to adjust cone width, dwell time, and air velocity in accordance with said schedule.

According to yet another embodiment, the controller is configured to coordinate operation with auxiliary air-circulation or purification devices by: establishing local communication links through Matter, Thread, Bluetooth Low Energy, or Wi-Fi protocols; exchanging operational parameters including airflow rate, filtration demand, and power status; and adjusting the predictive-control sub-model outputs so that combined airflow patterns enhance air-exchange efficiency while minimizing counterproductive turbulence.

According to yet another embodiment, the controller incorporates a safety subsystem configured to: monitor inertial-measurement data and base-load signals to detect tip-over onset; measure short-range time-of-flight or ultrasonic deltas to detect finger or object proximity; estimate motor-winding temperature using a thermal model; and initiate a controlled spin-down of the actuation system when any hazard threshold is exceeded.

According to yet another embodiment, a maintenance-diagnostic module is configured to: acquire vibration spectra, torque–RPM curves, and current harmonics during operation; compare the acquired parameters with reference profiles stored in memory to estimate dust loading, blade imbalance, or bearing wear; and generate a maintenance notification and optionally restrict maximum speed when degradation thresholds are exceeded.

According to yet another embodiment, the power-conversion and energy-management module comprises: active power-factor-correction circuitry configured to regulate input current; soft-start control circuitry configured to limit inrush current at startup; and a direct current (DC)-bus interface configured to manage charging and discharging of the energy-storage unit for brownout ride-through operation.

According to yet another embodiment, the energy-storage unit comprises a rechargeable battery pack and battery-management circuitry configured to monitor state of charge, control charging current, and supply standby power during grid interruptions.

According to yet another embodiment, the controller executes a night-mode profile by: receiving time-of-day or ambient-light inputs; modifying the predictive-control sub-model to reduce target airspeed and oscillation amplitude while maintaining the comfort index; and enforcing an acoustic threshold by limiting rotor acceleration and servo velocity to maintain quiet operation.

According to yet another embodiment, the neural-processing accelerator is configured to execute the perception sub-models, comfort-estimation sub models, and predictive-control sub-models concurrently by: partitioning incoming fused sensor data into separate processing pipelines; performing quantized neural-network inference using parallel cores; combining intermediate outputs to form an updated comfort-state vector; and supplying said vector to the predictive-control sub-model to compute real-time actuation parameters.

According to yet another embodiment, the controller is configured to preserve privacy by: processing all sensor data locally; storing only feature vectors and summary statistics instead of raw data; and encrypting and transmitting anonymized summaries solely for firmware updates or tariff synchronization.

According to yet another embodiment, the controller adapts the comfort-estimation sub-model over time by: receiving user feedback inputs or inferring preferences from behavioral cues; updating reinforcement-learning parameters; and storing updated model coefficients in non-volatile memory.

According to yet another embodiment, the actuation system employs field-oriented control of the BLDC motor and jerk-limited servo trajectories by generating motor-phase current references and servo-position profiles that minimize tonal noise and mechanical vibration.

According to yet another embodiment, the controller adjusts operational parameters in response to energy-tariff information by: receiving tariff data; updating the predictive-control sub-model cost function; and modifying airflow directionality and motor speed to reduce energy use while maintaining the comfort band.

Another embodiment of the present invention describes, a method for providing adaptive thermal comfort control by an artificial intelligence (AI) based fan system. The method comprises the steps of: (a) acquiring multimodal environmental and occupancy data from a privacy-preserving, camera-free sensor suite, the environmental data including temperature, relative humidity, barometric pressure, and air-quality indices, and the occupancy data including time-of-flight and ultrasonic ranging, passive-infrared transitions, acoustic activity level, and inertial motion; (b) fusing the acquired data in a controller comprising a microcontroller unit (MCU) and a neural-processing accelerator to produce one or more occupant vectors representing distance, bearing, and posture of users; (c) executing, on the neural-processing accelerator, an on-device artificial-intelligence model including: a perception sub-model trained to infer occupant localization and activity from fused sensor data; a comfort-estimation sub-model trained through reinforcement or bandit learning to map environmental conditions and user feedback to a personalized comfort index; and a predictive-control sub-model configured to compute optimal actuation parameters by minimizing a multi-objective cost function comprising comfort deviation, power consumption, and acoustic limits; (d) generating control signals from the predictive-control sub-model and transmitting the control signals to an actuation system comprising a BLDC motor and dual-axis servo drives; (e) controlling, in real time, the actuation system to adjust blade rotational speed, azimuth oscillation, and tilt angle through closed-loop field-oriented control; and (f) adaptively maintaining a target personalized comfort band by continuously repeating steps (a)–(e), updating model parameters based on user feedback and environmental variations, and operating locally without cloud dependence to minimize power consumption while preserving privacy.

BRIEF DESCRIPTION OF THE DRAWINGS

This invention is described by way of example with reference to the following drawings. These drawings being referred herein are for the purpose of illustrating preferred embodiments of the invention only, and not for the purpose of limiting the same.

Figure 1 illustrates a block diagram of an artificial-intelligence-based fan system configured to provide adaptive thermal comfort control, according to an embodiment of the present invention.

Figure 2 illustrates a block diagram of the neural-processing accelerator, according to an embodiment of the present invention.

Figure 3 illustrates a schematic representation of an AI-based adaptive fan system showing major components including the base, mast, gimbal head, and sensor suite, according to an embodiment of the present invention.

Figure 4 illustrates a flow chart of a method for providing adaptive thermal comfort control by an artificial intelligence based fan system, according to an embodiment of the present invention.

Figure 5 illustrates a flow chart of a method for providing adaptive thermal comfort control by an artificial intelligence based fan system, according to another embodiment of the present invention.

DETAILED DESCRIPTION OF THE ACCOMPANYING DRAWINGS

The present invention is described hereinafter by various embodiments with reference to the accompanying drawings, wherein reference numerals used in the accompanying drawings correspond to the like elements throughout the description. This invention may, however, be embodied in many different forms and should not be construed as limited to the embodiments set forth herein. Rather, the embodiments are provided so that this disclosure will be thorough and complete and will fully convey the scope of the invention to those skilled in the art.

It will be understood by those skilled in the art that the foregoing general description and the following detailed description are exemplary and explanatory of the invention and are not intended to be restrictive thereof. The terms "comprises", "comprising", or any other variations thereof, are intended to cover a non-exclusive inclusion, Appearances of the phrase "in an embodiment", "in another embodiment" and similar language throughout this specification may, but not necessarily do, all refer to the same embodiment.

Further, the words "a" or "an" mean "at least one” and the word “plurality” means “one or more” unless otherwise mentioned. Furthermore, the terminology and phraseology used herein is solely used for descriptive purposes and should not be construed as limiting in scope. The systems, methods, and examples provided herein are only illustrative and not intended to be limiting. The terms first edge, tubercles edge, and leading edge are used interchangeable hereinafter according to one or more embodiments. The terms second edge, serrated edge, trailing edge and serrated trailing edge are used interchangeable hereinafter according to one or more embodiments.

The present invention will now be described with reference to embodiments. It is to be understood that these embodiments are provided solely to illustrate the inventive concept and are not intended to limit the scope of the invention as defined by the claims. The invention relates to an artificial-intelligence **(**AI**)** based fan system that autonomously regulates airflow, direction, and velocity in response to environmental and occupancy conditions. The system employs an embedded controller with a neural-processing accelerator to execute local AI models for perception, comfort estimation, and predictive control. The overall architecture integrates multimodal sensing, intelligent power conversion, energy management, and a multi-axis actuation mechanism within a compact mechanical form factor.

Figure 1 illustrates a block diagram of an artificial-intelligence-based fan system **100** configured to provide adaptive thermal comfort control, according to an embodiment of the present invention.

The artificial-intelligence-based fan system **100** comprises a base unit **102,** a mast **104,** privacy-preserving, camera-free sensor suite **106,** a controller **108**, and an actuation subsystem **110**. The base unit **102** configured to accommodate a power-conversion and energy-management module **112** and an energy-storage unit **114**. The fan system **100** comprises a vertical mast and a weighted base configured as a standing fan.

.The power-conversion and energy-management module **112** comprises an AC-DC converter with active power-factor correction (PFC) circuitry for line regulation, a DC-DC converter to generate regulated voltage rails, and soft-start circuitry to limit inrush current.

The energy-storage unit **114**, such as a rechargeable lithium-ion battery pack, is managed by a battery-management subsystem (BMS) configured to monitor cell voltage, temperature, and state of charge. This configuration ensures safe operation during voltage fluctuations and enables short-term autonomous operation in case of grid interruptions.

The mast **104** connects the base to a two-axis gimbal head that provides independent control over azimuth and tilt. A gimbal head houses a brushless-DC (BLDC) motor, a low-turbulence aerodynamic blade assembly, and acoustic diffusers to reduce flow-induced noise. Dual-axis servo drives are coupled to the gimbal frame to allow oscillation and tilt motions within predetermined angular limits. Motion trajectories are governed by jerk-limited profiles to minimize mechanical vibration and resonance.

The fan system **100** incorporates a privacy-preserving**,** camera**-**free sensor suite **106** positioned across the gimbal and base. In one embodiment, the sensor suite **106** comprises one or more environmental sensors and one or more occupancy and proximity sensors.

The environmental sensors includes temperature, relative humidity, barometric pressure, and air-quality sensors (CO_2, VOC, $PM_{2.5}$).

The occupancy and proximity sensors**,** includes time-of-flight (ToF) rangefinders**,** ultrasonic transducers**,** passive-infrared (PIR) detectors**,** acoustic microphones**,** and inertial measurement units (IMU)**.**

Sensor data are pre-processed and synchronized using timestamp correlation and low-pass filtering. The fused dataset enables three-dimensional estimation of user distance, bearing, and posture without the need for image or video capture, thereby ensuring complete privacy.

The controller **108** comprises a microcontroller unit (MCU) **116** and a neural-processing accelerator (NPU) **118**. The microcontroller unit (MCU) **116** is configured to perform real-time tasks such as sensor acquisition, data synchronization, safety interlocks, and low-level motor-control loops. The neural-processing accelerator (NPU) **118** configured to execute an on-device artificial-intelligence model.

The MCU **116** communicates with the NPU **118** via a shared-memory interface, allowing streaming of fused sensor data and reception of inference results with minimal latency.

The controller **108** further integrates non-volatile memory for storing trained model parameters, configuration data, and user profiles.

The fan system **100** further comprises a maintenance-diagnostic module (120). The maintenance-diagnostic module **120** is configured to acquire vibration spectra, torque–RPM curves, and current harmonics during operation, compare the acquired parameters with reference profiles stored in memory to estimate dust loading, blade imbalance, or bearing wear, and generate a maintenance notification and optionally restrict maximum speed when degradation thresholds are exceeded.

Figure 2 illustrates a block diagram of the neural-processing accelerator (NPU) **118**, according to an embodiment of the present invention. The neural-processing accelerator (NPU) **118** configured to execute an on-device artificial-intelligence model. In one embodiment, the artificial-intelligence model comprises three sub-models executed concurrently on the NPU **118**. Three sub-models comprises a perception sub-model **202**, comfort-estimation sub-model **204** and a predictive-control sub-model **206.**

The perception sub-model **202** is configured to processes fused ToF, ultrasonic, PIR, acoustic, and motion data to infer occupant localization, activity level, and presence confidence. The perception sub-model **202** employs quantized convolutional or transformer layers trained using labeled occupancy datasets.

The comfort-estimation sub-model **204** is configured to implement a reinforcement or contextual bandit learning algorithm that maps sensed temperature, humidity, air quality, and user feedback (e.g., button inputs, gesture cues, or duration of exposure) to a personalized comfort index. The comfort-estimation sub-model **204** continuously adapts reward parameters to reflect occupant preferences over time.

The predictive-control sub-model **206** configured to utilizes the outputs of the previous sub-models to compute optimal actuation parameters — including fan speed, oscillation amplitude, sweep profile, and tilt angle — by minimizing a multi-objective cost function that balances comfort deviation, power consumption, and acoustic output. The predictive-control sub-model **206** forecasts environmental disturbances such as drafts or heat sources and adjust actuation pre-emptively.

All three sub-models **202**, **204**, **206** operate under a real-time inference scheduler to ensure sub-100-millisecond latency suitable for comfort control loops.

The actuation subsystem **110** comprises the BLDC motor and dual-axis servo drives. Motor control is implemented using field-oriented control **(**FOC**)** algorithms executed on the MCU 116. The controller **108** regulates phase currents, torque, and rotational speed using closed-loop feedback from Hall or magnetic encoders. Servo drives for azimuth and tilt employ positional feedback to maintain precise airflow orientation. Combined motor and servo commands are generated based on predictive-control sub-model outputs.

Figure 3 illustrates a schematic representation of an AI-based adaptive fan system **300** showing major components including the base, mast, gimbal head, and sensor suite, according to an embodiment of the present invention.

In one embodiment, the present invention describes an AI-based smart standing fan that comprises a weighted base, telescopic mast, and a two-axis gimbal head carrying a high-efficiency brushless DC (BLDC) rotor, stator, and low-turbulence blade assembly enclosed by a safety grille with aero-acoustic diffusers. The base houses power electronics, an optional battery pack, and a sensor cap. The sensor suite includes temperature, relative humidity, and barometric sensors; a tVOC/PM sensor for indoor air quality; a 6-axis IMU for vibration and tip-over detection; time-of-flight and ultrasonic ranging modules for occupant localization and finger proximity; passive infrared for motion onset; a low-resolution acoustic module for activity cues; and Hall/optical encoders on the gimbal axes and rotor. A control board integrates a microcontroller, motor driver, secure element, and a lightweight neural accelerator.

Operation begins with continuous acquisition of ambient and positional data at defined sampling rates. A perception pipeline fuses time-of-flight ranges, ultrasonic echoes, PIR transitions, and acoustic energy profiles to estimate one or more occupant vectors (bearing, distance, approximate elevation, motion state) without capturing imagery. Simultaneously, a comfort estimator derives a personalized comfort score from temperature, humidity, local air speed proxy, and recent user feedback (button taps, app sliders, or passive dwell time near preferred settings). The estimator runs on-device and updates model parameters incrementally to adapt to seasons and individual preferences while respecting safety envelopes for airflow, noise, and thermal limits.

Actuation is orchestrated by a multi-objective controller that selects rotor RPM, azimuth oscillation amplitude, phase dwell, sweep rate, and tilt angle to maximize perceived comfort per unit power. The controller **108** computes transit time of the air jet to each tracked occupant and coordinates gimbal motion with rotor torque so that narrow, higher-velocity pulses cross long distances and broaden into softer streams near the target. For multi-occupant scenarios, a fairness scheduler time-divides the airflow by need, distance, and policy (equal share, energy-biased, or priority), dynamically shaping cone width and dwell time to prevent starvation. Disturbance models derived from pressure and acoustic cues predict door openings or drafts; the head pre-positions and the rotor pre-ramps to avoid comfort overshoot.

Safety and reliability functions run in parallel watchdog loops. The IMU, base load cell (optional), and encoder torque estimates feed a tip-over predictor that triggers controlled spin-down and gimbal lock if instability is detected. Proximity thresholds from time-of-flight and ultrasonic deltas pause rotation when hands approach the grille. A motor-thermal digital twin derates torque to keep winding temperatures within limits, while vibration spectral analysis and torque-RPM curve monitoring infer dust loading, blade imbalance, and bearing wear. The device issues maintenance prompts with actionable guidance (cleaning interval, balance check) and logs anonymized summaries locally for trend analysis. All core functions operate offline; optional connectivity (Thread/Matter, BLE, or Wi-Fi) enables tariff schedules, firmware updates, and coordination with purifiers or ceiling fans.

Power electronics include active power-factor correction, soft-start, and a high-efficiency buck stage for logic rails. The optional battery module supports brownout ride-through and peak-tariff modes that bias toward directional airflow at lower RPM. Mechanical design emphasizes low-noise bearings, click-fit grille for cleaning, and a modular gimbal for serviceability. Firmware is secured with authenticated boot and signed updates, and the data path avoids raw audio storage or personally identifiable information. Through this integration of privacy-preserving perception, personalized comfort estimation, predictive airflow shaping, fair multi-user scheduling, and predictive safety/maintenance, the fan functions as an autonomous comfort appliance adaptable to homes, clinics, classrooms, and small commercial spaces.

Figure 4 illustrates a flow chart of a method **400** for providing adaptive thermal comfort control by an artificial intelligence based fan system **100**, **300**, according to an embodiment of the present invention.

Start → Power On & Self-Test

When the fan powers up, it performs a secure boot and a hardware self-test. It checks power rails, memory CRCs, motor driver status, encoder feedback on the gimbal axes, IMU presence, and basic sensor sanity (temperature/humidity/pressure/TVOC, ToF/ultrasonic, PIR, acoustic). It also verifies button/LEDs, communication buses (I^2C/SPI/UART), and optional battery health. If anything fails, the system won't spin the rotor.

Decision: Check for pass state of Self-test

If the self-test fails, control moves to a safe state: rotor disabled, gimbal locked, a fault code is logged and signaled to the user; a manual reset or service is required. If it passes, the system continues to sensor initialization and calibration.

Initialize Sensors & Sensor Fusion

All sensors are zeroed and calibrated. Temperature/humidity/pressure baselines are established; the TVOC/PM sensor warms up and stabilizes; ToF/ultrasonic modules measure empty-room ranges to set noise thresholds; PIR sensitivity is tuned; the IMU biases are estimated; gimbal and rotor encoders are zeroed. A fusion module then aggregates these streams into a single state vector with time sync and confidence scores.

Occupant Localization & Tracking

Using ToF/ultrasonic ranging, PIR transitions, acoustic energy cues, and the head's own pose, the fan estimates occupant bearings, distances, and rough elevation (seated/standing). A tracker (e.g., Kalman/particle filter) maintains one or more "occupant tracks," handles occlusions, and smooths motion. The same pipeline flags hazards: near-grille finger approach, tip-over onset from IMU tilt/jerk, and cable strain spikes.

Control (Policy Optimization: Comfort/Power/Safety)

The controller **108** computes a target “comfort score” from room conditions (temperature, humidity), learned user preferences (noise tolerance, breeze strength, sleep mode), and occupancy geometry. It optimizes a cost function that trades comfort error, power draw, and acoustic limits subject to safety constraints. For multiple occupants, a fairness scheduler time-shares airflow by allocating dwell time and cone width so no one is starved.

Actuation Control (BLDC RPM, Oscillation Angle, Tilt)

Closed-loop motor control (e.g., FOC) sets blade RPM. Gimbal servos set azimuth and tilt. The controller **108** “phase-shapes” sweeps: it narrows the cone and briefly increases RPM to cross long distances, then widens/softens near the target to avoid buffeting and tonal peaks. Ramps have jerk limits for quietness. Draft predictors (door/window events inferred from pressure/acoustic cues) pre-position the head and pre-ramp RPM to avoid overshoot.

Airflow Delivery (Feedback Loop)

As air is delivered, the system samples quick feedback: local temperature/humidity deltas, motor torque/current, vibration, and occupant response (lingering vs turning away). It nudges setpoints to hit the comfort band with the least energy. Night profiles send gentle micro-breeze pulses and enforce strict noise ceilings. If the room empties, the fan enters an energy-saving idle with brief scan sweeps to detect re-entry.

Maintenance Diagnostics (Parallel Lane)

A background task analyzes vibration spectra, torque-RPM curves, and current harmonics to estimate dust loading, blade imbalance, and bearing wear. It monitors motor winding temperature models, grill blockage, and filter coordination with any attached purifier. When thresholds are crossed, it schedules a cleaning/balance reminder and can auto-limit RPM to keep noise and stress within bounds until service.

Decision: Check for need for Maintenance

If maintenance is due, the fan notifies the user (display/app/LED) and can defer aggressive modes that would worsen wear. If not, normal operation continues. This branch runs continuously and doesn't interrupt safety-critical control.

Decision: Check for presence of Occupant

If no occupant is detected for a configured dwell time, the fan moves to low-power idle: the head parks, RPM drops to near zero, and periodic sensor pings maintain awareness. If an occupant is detected, control flows into the comfort optimization and actuation loop for targeted airflow.

Emergency Stop (Watchdog Path)

At any point, hazard triggers—tip-over detection from IMU and base sensors, finger proximity at the grille from ToF/ultrasonic deltas, over-current/over-temp in the motor driver, or cable pull—cause an immediate, controlled stop: rotor ramps down rapidly, gimbal locks, and a fault is logged and signaled. Recovery requires conditions to return to safe ranges and, if configured, a user acknowledgment.

Reboot / Shutdown

For firmware updates, persistent faults, or user command, the system performs an orderly shutdown: it writes logs, parks the gimbal, saves learned preferences, and powers down high-current stages. On reboot, it resumes with the last known safe configuration and re-runs self-test and calibration to ensure integrity.

Privacy & Offline Operation (Design Principle)

All perception and control run on-device; no camera is used. Only anonymized summaries leave the device (if the user enables cloud features). This keeps latency low, reliability high during internet outages, and protects user privacy while still enabling autonomous, adaptive comfort.

Figure 5 illustrates a flow chart of a method **500** for providing adaptive thermal comfort control by an artificial-intelligence-based fan system **100, 300**, according to another embodiment of the present invention.

At step **502**, the method describes acquiring multimodal environmental and occupancy data from a privacy-preserving, camera-free sensor suite, the environmental data including temperature, relative humidity, barometric pressure, and air-quality indices, and the occupancy data including time-of-flight and ultrasonic ranging, passive-infrared transitions, acoustic activity level, and inertial motion.

At step **504**, the method describes fusing the acquired data in a controller **108** comprising a microcontroller unit (MCU) and a neural-processing accelerator to produce one or more occupant vectors representing distance, bearing, and posture of users;

At step **506**, the method describes executing, on the neural-processing accelerator, an on-device artificial-intelligence model including:

a perception sub-model trained to infer occupant localization and activity from fused sensor data;

a comfort-estimation sub-model trained through reinforcement or bandit learning to map environmental conditions and user feedback to a personalized comfort index; and

a predictive-control sub-model configured to compute optimal actuation parameters by minimizing a multi-objective cost function comprising comfort deviation, power consumption, and acoustic limits;

At step **508**, the method describes generating control signals from the predictive-control sub-model and transmitting the control signals to an actuation subsystem comprising a BLDC motor and dual-axis servo drives;

At step **510**, the method describes controlling, in real time, the actuation subsystem to adjust blade rotational speed, azimuth oscillation, and tilt angle through closed-loop field-oriented control; and

At step **512**, the method describes adaptively maintaining a target personalized comfort band by continuously repeating steps (a)–(e), updating model parameters based on user feedback and environmental variations, and operating locally without cloud dependence to minimize power consumption while preserving privacy.

Operational Workflow

During operation, the system performs the following steps:

1. **Initialization:** Sensor calibration, power-up diagnostics, and retrieval of stored model parameters.
2. **Data Acquisition:** Continuous collection of environmental and occupancy data.
3. **Sensor Fusion:** Synchronization and fusion to derive occupant vectors.
4. **Inference:** Execution of AI sub-models to estimate comfort and compute control commands.
5. **Actuation:** Real-time adjustment of fan speed, oscillation, and tilt via FOC and servo drivers.
6. **Learning Update:** Feedback-based reinforcement updates to personalize comfort preferences.
7. **Energy Optimization:** Dynamic adjustment of actuation cost weighting in response to tariff or battery status.

This closed-loop cycle operates autonomously and locally, without dependence on remote servers.

Safety and Maintenance

The controller **108** continuously monitors vibration spectra, current harmonics, and thermal parameters to detect imbalance, bearing wear, or overheating. If unsafe conditions are detected, the system initiates a controlled spin-down and displays diagnostic indicators.

Periodic self-checks ensure calibration consistency and alert users for cleaning or servicing when dust accumulation exceeds threshold levels.

Communication and Integration

In one embodiment, the artificial-intelligence-based fan system **100** configured to communicate with auxiliary air-circulation or purification devices through Matter, Thread, Bluetooth Low Energy **(**BLE**)**, or Wi-Fi protocols. All data exchanged are encrypted and limited to operational parameters such as airflow rate and energy status. The controller **108** may also receive tariff or schedule information for energy-aware optimization.

Advantages

The present invention provides numerous advantages which includes but not limited to

- On-device intelligence for real-time, adaptive comfort control without cloud dependence.
- Enhanced privacy through camera-free sensing.
- Predictive actuation anticipating environmental changes.
- Multi-objective optimization balancing comfort, power efficiency, and acoustic performance.
- Self-learning adaptation to user preferences over time.
- Safety, diagnostic, and maintenance functionality integrated within the same control framework.

EXAMPLES / WORKING OF THE INVENTION

The invention has been reduced to practice in several prototype configurations to validate its performance in maintaining personalized thermal comfort, minimizing energy use, and ensuring low acoustic output. The following examples illustrate representative embodiments of the working of the invention.

Example 1: Construction and Power Management

A prototype fan system was constructed with a base housing fabricated from composite polymer with integrated heat-dissipation fins. The base incorporated a power-conversion module consisting of:

- an AC–DC converter rated at 120 W with active power-factor correction **(**PFC**)** achieving >0.95 PF;
- a DC-bus of 24 V regulated by a synchronous buck converter; and
- an energy-storage unit comprising a 3-cell lithium-ion pack (nominal 10.8 V, 2.6 Ah) managed by a battery-management subsystem.

The module ensured stable operation during voltage fluctuations and provided up to 15 minutes of autonomous runtime during grid interruption. The conversion efficiency exceeded 91 % at nominal load.

Example 2: Sensor Fusion and Occupancy Detection

The sensor suite included a temperature–humidity sensor, barometric sensor, CO_2 and VOC detectors, ultrasonic rangefinders, time-of-flight sensors, PIR detectors, and a microphone array for acoustic activity sensing.

Sensor sampling occurred at 10 Hz, and data were fused using a Kalman-based estimator implemented on the MCU **(**ARM Cortex-M7**)**. The fused data generated occupant vectors with an average spatial-localization error of less than 12 cm at a 2.5 m distance.

Testing in a 25 m² room with two occupants demonstrated accurate discrimination of seated and standing postures as well as user movement between zones. No visual or personally identifiable data were captured during operation, verifying the privacy-preserving feature of the invention.

Example 3: AI Model Execution and Predictive Control

The neural-processing accelerator **(**NPU**)** integrated a 512-core parallel array operating at 400 MHz, executing the perception, comfort-estimation, and predictive-control sub-models concurrently.

- The perception model employed a quantized convolutional neural network trained on 50 000 synthetic occupancy vectors.
- The comfort-estimation model applied a contextual bandit learning approach with a reward function combining user feedback, temperature deviation, and acoustic comfort score.
- The predictive-control model executed a model-predictive control (MPC) optimization at a 100 ms cycle time.

Latency between sensor acquisition and actuation command generation was consistently below 80 ms, ensuring perceptible real-time response. The predictive model pre-emptively increased airflow within 0.2 s of a detected door-opening event.

Example 4: Actuation and Comfort Regulation

The BLDC motor (100 W, 24 V, 12-pole) operated under field-oriented control **(**FOC**)** using three-phase Hall feedback. Dual-axis servo drives controlled azimuth and tilt with ±45° and ±20° range respectively.

When tested under varying environmental conditions (temperature: 24–30 °C, humidity: 35–70 %), the system maintained the personalized comfort index within ±5 % of the target band while reducing average power consumption by 27 % compared to constant-speed operation.

Acoustic measurements indicated sound pressure levels of below 36 dBA at 1 m distance during normal operation, attributed to the optimized blade geometry and jerk-limited servo motion.

Example 5: Self-Learning and Adaptation

During continuous operation for 72 hours, the comfort-estimation sub-model adapted its parameters based on implicit feedback derived from user proximity and motion cues. After five feedback cycles, the predicted comfort index converged within **±2 %** of subjective user ratings obtained through a companion interface.

The model's reinforcement-learning adaptation resulted in a 15 % improvement in steady-state comfort efficiency after repeated exposure to similar ambient conditions.

Example 6: Safety and Diagnostic Performance

The system's safety subsystem monitored inertial, ultrasonic, and temperature parameters. Simulated tip-over and obstruction events were detected within 20 ms, triggering immediate motor spin-down.

The maintenance-diagnostic module accurately detected induced blade imbalance (>5 g mass offset) via vibration analysis and issued a maintenance alert through the user interface.

Example 7: Integration and Energy Optimization

In a multi-device configuration, the AI fan communicated with an external air-purifier and ventilation module via Matter over Wi-Fi protocol. Shared operational data enabled coordinated airflow scheduling that improved air-exchange rate by 18 % while maintaining total system power below 90 W.

When operated in time-of-use tariff mode, the predictive controller automatically reduced motor duty cycle during high-tariff periods, achieving an additional 12 % reduction in energy cost.

The foregoing description describes embodiments of the present invention. It should be appreciated that these embodiments are described for the purpose of illustration only, and that numerous alterations and modifications may be practiced by those skilled in the art without departing from the scope of the invention. It is intended that all such modifications and alterations be included in so far as they come within the scope of the invention as claimed or the equivalents thereof.

We Claim:

1. An artificial intelligence (AI) based fan system (100) configured to provide adaptive thermal comfort control, comprising:

a base unit (102) configured to accommodate a power-conversion and energy-management module (112) and an energy-storage unit (114),

the power-conversion and energy-management module (112) being configured to supply regulated electrical power to a controller (108) and an actuation subsystem (110);

a mast (104) supporting a two-axis gimbal head comprising a brushless-Direct Current (BLDC) motor, a low-turbulence blade assembly, and acoustic diffusers for low-noise airflow;

a privacy-preserving, camera-free sensor suite (106) configured to acquire multimodal data comprising:

environmental parameters including temperature, relative humidity, barometric pressure, and air-quality indices; and

occupancy parameters including time-of-flight and ultrasonic ranging, passive-infrared transitions, acoustic activity level, and inertial motion,

wherein the sensor suite (106) is arranged to generate fused occupant vectors representing distance, bearing, and posture of one or more users without capturing images or personally identifiable data;

the controller (108) comprising:

a microcontroller unit (MCU) (116) configured to perform real-time sensor fusion, safety monitoring, and motor-control operations; and a neural-processing accelerator (118) configured to execute an on-device artificial-intelligence model including:

a perception sub-model (202) trained to infer occupant localization and activity from fused time-of-flight, ultrasonic, acoustic, and motion data;

a comfort-estimation sub-model (204) trained through reinforcement or bandit learning to map sensed environmental parameters and user feedback to a personalized comfort index; and

a predictive-control sub-model (206) configured to compute optimal actuation parameters by minimizing a multi-objective cost function incorporating comfort deviation, power consumption, and acoustic limits;

the actuation subsystem (110) comprising the BLDC motor and dual-axis servo drives configured to control blade rotational speed, azimuth oscillation, and tilt angle through closed-loop field-oriented control; and

the controller (108) continuously fuses said multimodal sensor data, executes said sub-models on the neural-processing accelerator, and, based on the predictive-control output, adaptively adjusts fan speed, oscillation amplitude, sweep profile, and tilt angle to maintain a target personalized comfort band with minimum power draw while operating locally without cloud dependence.

2. The fan system as claimed in claim 1, wherein the controller (108) is configured to anticipate environmental disturbances including door openings, window drafts, or heat plumes by:

continuously monitoring acoustic signatures and barometric-pressure variations obtained from the sensor suite (106);

detecting transient patterns corresponding to sudden pressure drops, localized noise bursts, or airflow shifts;

predicting a disturbance event through inference by the predictive-control sub-model based on said transient patterns; and

pre-positioning the gimbal head and pre-ramping the BLDC motor speed prior to the detected event, whereby airflow direction and magnitude are adjusted in advance to prevent comfort overshoot or airflow lag.

3. The fan system as claimed in claim 1, wherein the controller (108) comprises a fairness-scheduling module configured to allocate airflow among multiple occupants by:

tracking the location and comfort index of each occupant using fused sensor data and the comfort-estimation sub-model;

computing a priority or dwell-time weight for each occupant according to a fairness policy;

generating an airflow-allocation schedule defining sequential or overlapping airflow cones; and

commanding the actuation subsystem (110) to adjust cone width, dwell time, and air velocity in accordance with said schedule.

4. The fan system as claimed in claim 1, wherein the controller (108) is configured to coordinate operation with auxiliary air-circulation or purification devices by:

establishing local communication links through Matter, Thread, Bluetooth Low Energy, or Wi-Fi protocols;

exchanging operational parameters including airflow rate, filtration demand, and power status; and

adjusting the predictive-control sub-model outputs so that combined airflow patterns enhance air-exchange efficiency while minimizing counterproductive turbulence.

5. The fan system as claimed in claim 1, wherein the controller (108) incorporates a safety subsystem configured to:

monitor inertial-measurement data and base-load signals to detect tip-over onset;

measure short-range time-of-flight or ultrasonic deltas to detect finger or object proximity;

estimate motor-winding temperature using a thermal model; and

initiate a controlled spin-down of the actuation subsystem (110) when any hazard threshold is exceeded.

6. The fan system as claimed in claim 1, wherein a maintenance-diagnostic module (120) is configured to:

acquire vibration spectra, torque–RPM curves, and current harmonics during operation;

compare the acquired parameters with reference profiles stored in memory to estimate dust loading, blade imbalance, or bearing wear; and

generate a maintenance notification and optionally restrict maximum speed when degradation thresholds are exceeded.

7. The fan system as claimed in claim 1, wherein the power-conversion and energy-management module (112) comprises:

active power-factor-correction circuitry configured to regulate input current;

soft-start control circuitry configured to limit inrush current at startup; and

a direct current (DC)-bus interface configured to manage charging and discharging of the energy-storage unit (114) for brownout ride-through operation.

8. The fan system as claimed in claim 1, wherein the energy-storage unit (114) comprises a rechargeable battery pack and battery-management circuitry configured to monitor state of charge, control charging current, and supply standby power during grid interruptions.

9. The fan system as claimed in claim 1, wherein the controller (108) executes a night-mode profile by:

receiving time-of-day or ambient-light inputs;

modifying the predictive-control sub-model to reduce target airspeed and oscillation amplitude while maintaining the comfort index; and

enforcing an acoustic threshold by limiting rotor acceleration and servo velocity to maintain quiet operation.

10. The fan system as claimed in claim 1, wherein the neural-processing accelerator (118) is configured to execute the perception sub-models, comfort-estimation sub models, and predictive-control sub-models concurrently by:

partitioning incoming fused sensor data into separate processing pipelines;

performing quantized neural-network inference using parallel cores;

combining intermediate outputs to form an updated comfort-state vector; and

supplying said vector to the predictive-control sub-model to compute real-time actuation parameters.

11. The fan system as claimed in claim 1, wherein the controller (108) is configured to preserve privacy by:

processing all sensor data locally;

storing only feature vectors and summary statistics instead of raw data; and

encrypting and transmitting anonymized summaries solely for firmware updates or tariff synchronization.

12. The fan system as claimed in claim 1, wherein the controller (108) adapts the comfort-estimation sub-model over time by:

receiving user feedback inputs or inferring preferences from behavioral cues;

updating reinforcement-learning parameters; and

storing updated model coefficients in non-volatile memory.

13. The fan system as claimed in claim 1, wherein the actuation subsystem (110) employs field-oriented control of the BLDC motor and jerk-limited servo trajectories by generating motor-phase current references and servo-position profiles that minimize tonal noise and mechanical vibration.

14. The fan system as claimed in claim 1, wherein the controller (108) adjusts operational parameters in response to energy-tariff information by:

receiving tariff data;

updating the predictive-control sub-model cost function; and

modifying airflow directionality and motor speed to reduce energy use while maintaining the comfort band.

15. A method for providing adaptive thermal comfort control by an artificial intelligence (AI) based fan system, comprising the steps of:

a) acquiring multimodal environmental and occupancy data from a privacy-preserving, camera-free sensor suite, the environmental data including temperature, relative humidity, barometric pressure, and air-quality indices, and the occupancy data including time-of-flight and ultrasonic ranging, passive-infrared transitions, acoustic activity level, and inertial motion;

b) fusing the acquired data in a controller comprising a microcontroller unit (MCU) and a neural-processing accelerator to produce one or more occupant vectors representing distance, bearing, and posture of users;

c) executing, on the neural-processing accelerator, an on-device artificial-intelligence model including:

a perception sub-model trained to infer occupant localization and activity from fused sensor data;

a comfort-estimation sub-model trained through reinforcement or bandit learning to map environmental conditions and user feedback to a personalized comfort index; and a predictive-control sub-model configured to compute optimal actuation parameters by minimizing a multi-objective cost function comprising comfort deviation, power consumption, and acoustic limits;

d) generating control signals from the predictive-control sub-model and transmitting the control signals to an actuation subsystem comprising a BLDC motor and dual-axis servo drives;
e) controlling, in real time, the actuation subsystem to adjust blade rotational speed, azimuth oscillation, and tilt angle through closed-loop field-oriented control; and
f) adaptively maintaining a target personalized comfort band by continuously repeating steps (a)–(e), updating model parameters based on user feedback and environmental variations, and operating locally without cloud dependence to minimize power consumption while preserving privacy.

Dated this 10th day of November 2025

Signature

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(Anuradha Gupta)
Patent Agent (IN/PA-1514)
Agent for the Applicant

ABSTRACT

AI BASED SMART STANDING FAN

The present invention discloses an artificial-intelligence-based fan system **100** configured to provide adaptive thermal comfort control and method thereof. The fan system **100** comprises a base unit **102,** a mast **104,** a privacy-preserving, camera-free sensor suite **106,** a controller **108,** and an actuation subsystem **110.** The base unit **102** configured to accommodate a power-conversion and energy-management module **112** and an energy-storage unit **114**. The mast is configured to provide support to a two-axis gimbal head, a privacy-preserving, camera-free sensor suite **106** configured to acquire multimodal data, a controller, and an actuation subsystem **110**. The controller comprises a microcontroller unit (MCU) **116** configured to perform real-time sensor fusion, safety monitoring, and motor-control operations, and a neural-processing accelerator **118** configured to execute an on-device artificial-intelligence model. The actuation subsystem comprises the BLDC motor and dual-axis servo drives configured to control blade rotational speed, azimuth oscillation, and tilt angle through closed-loop field-oriented control.

Figure 1

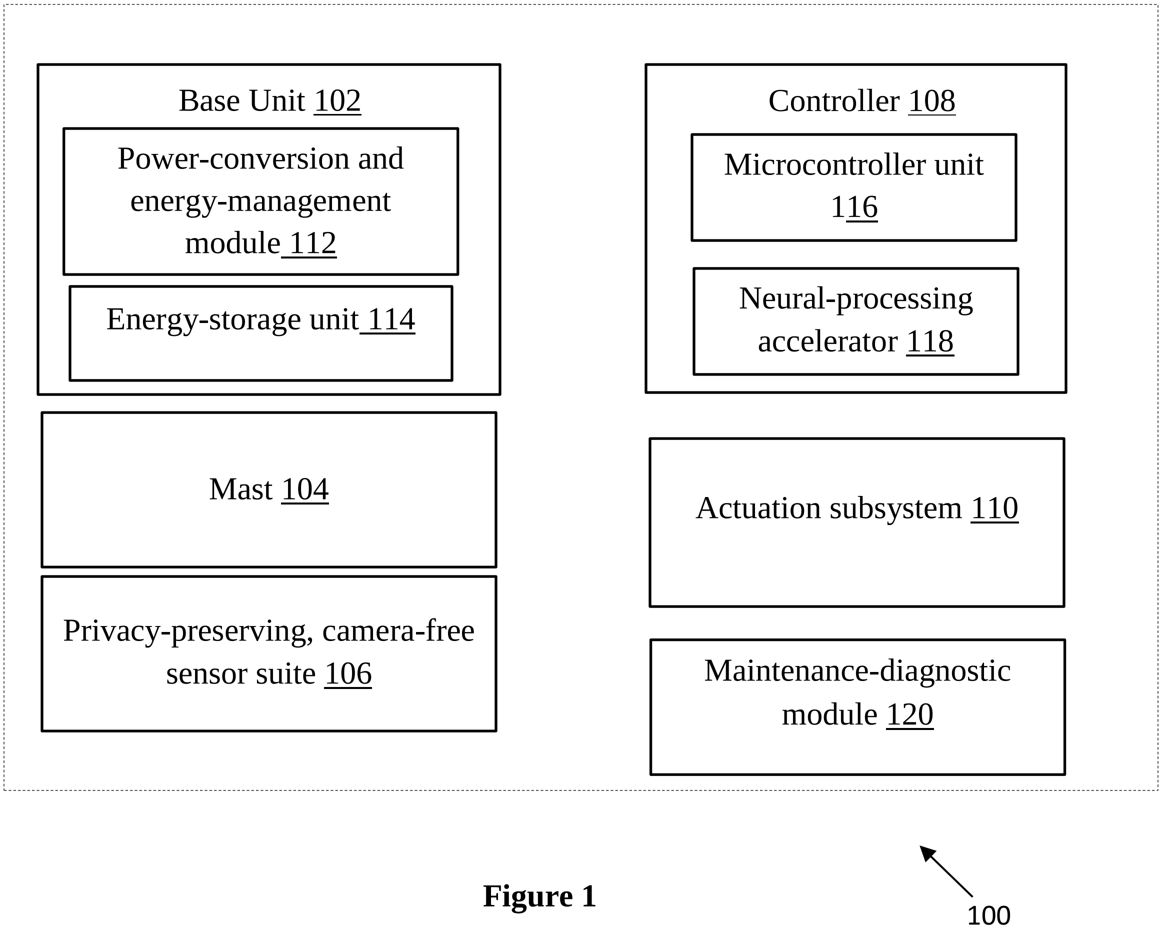

Figure 1

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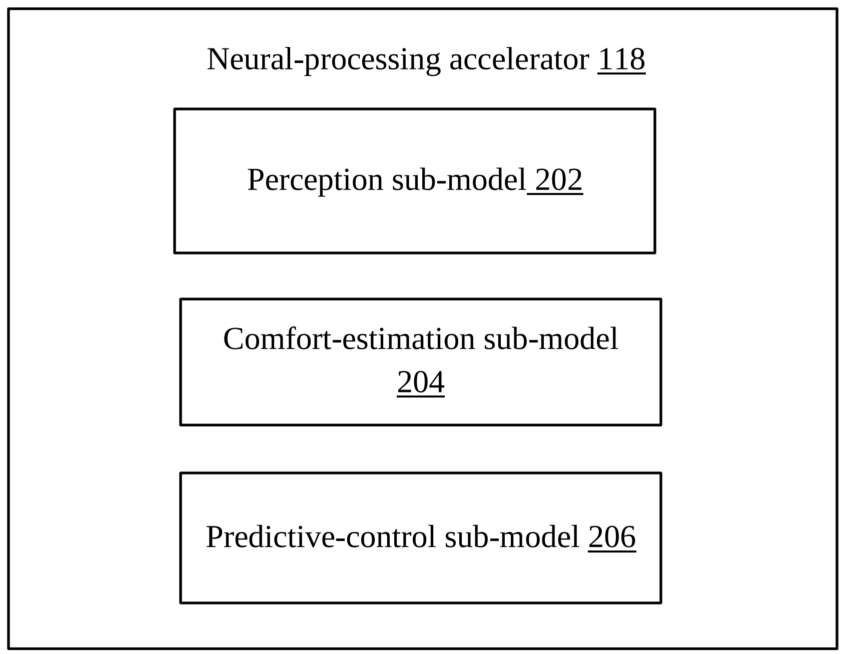

Figure 2

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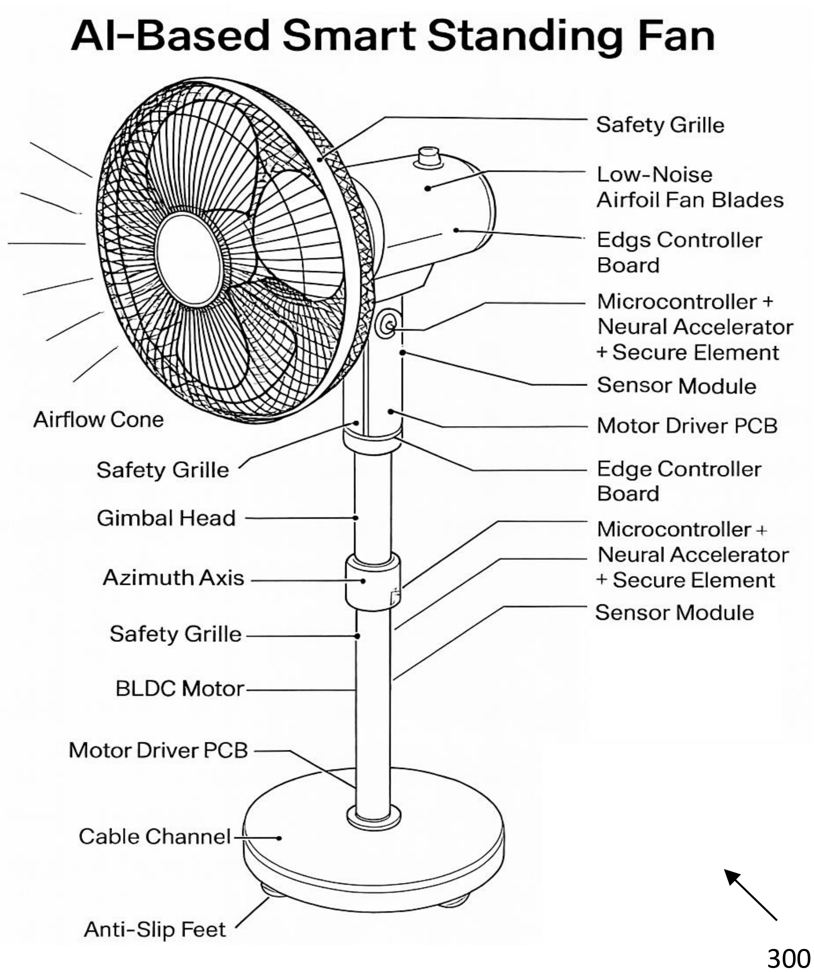

Figure 3

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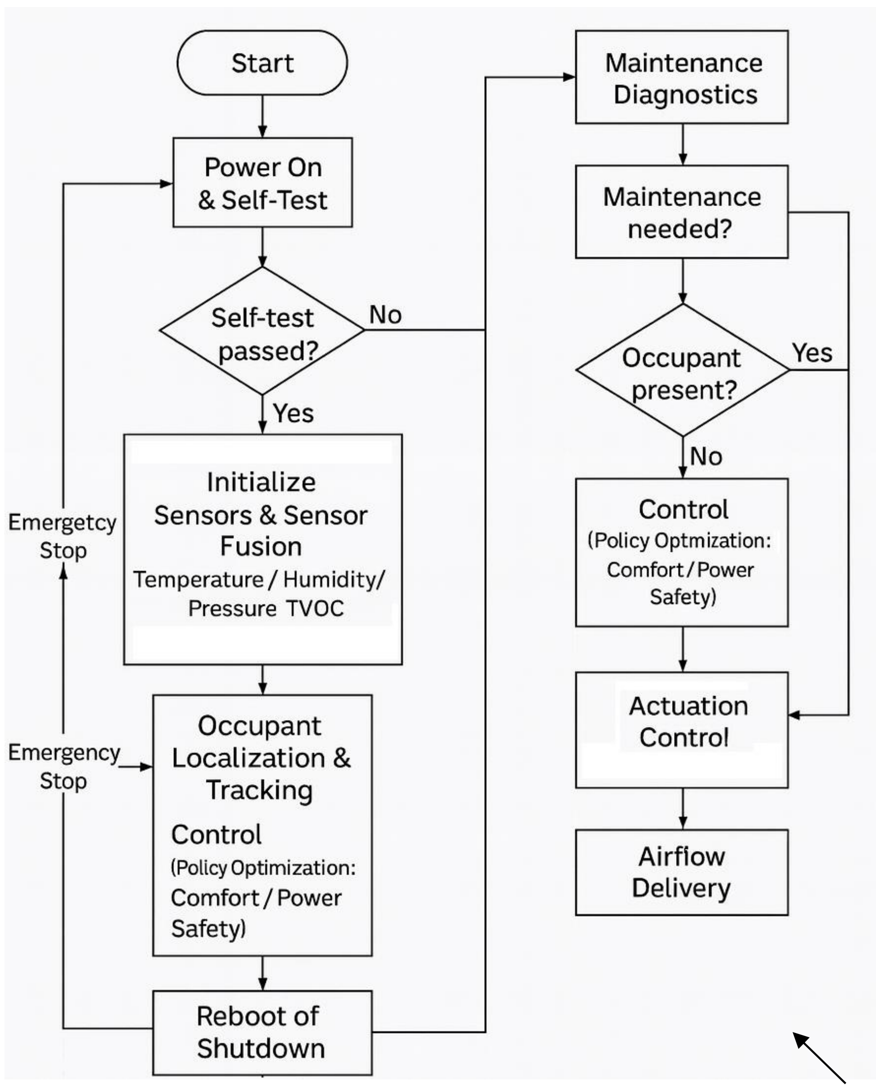

400

Figure 4

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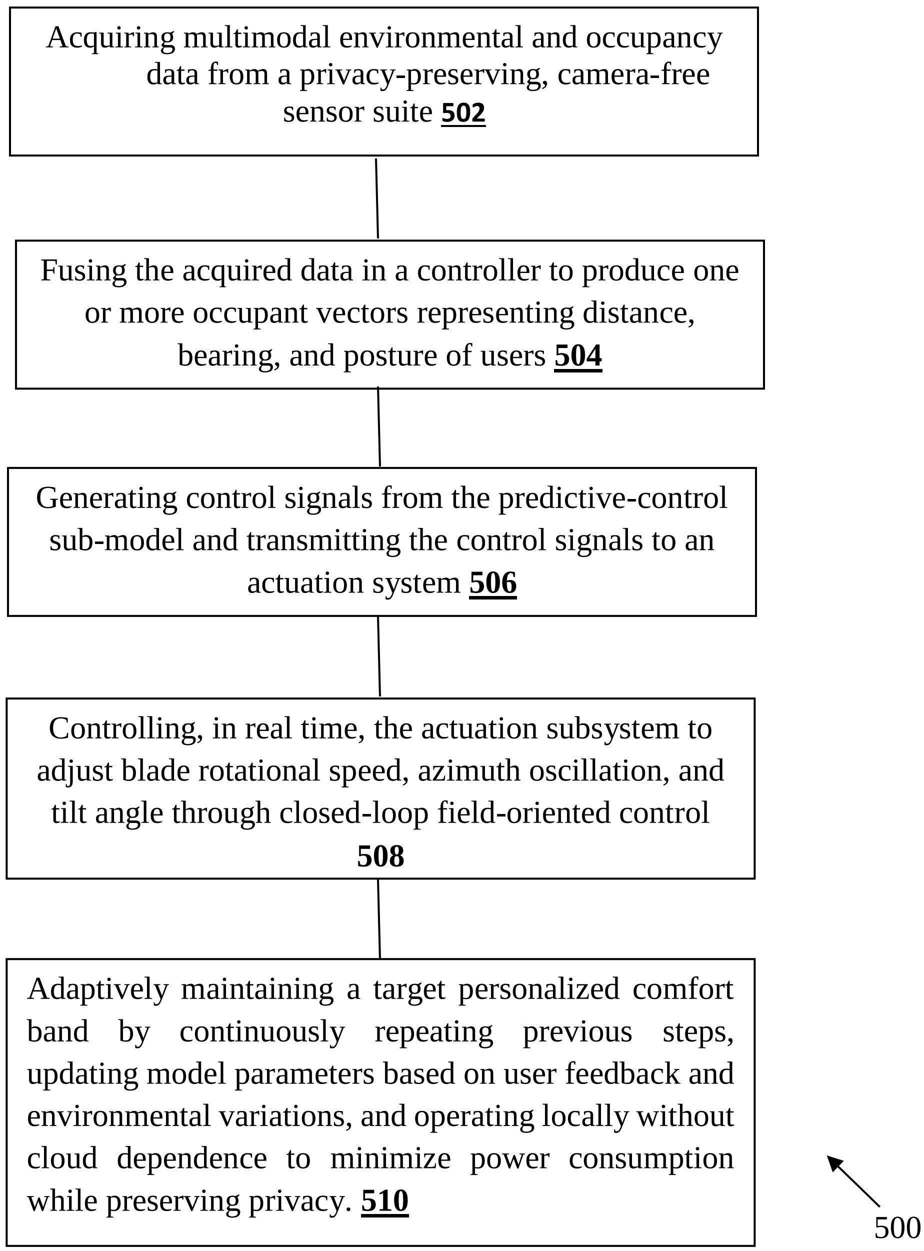

Figure 5

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"FORM 1 THE PATENTS ACT 1970 (39 of 1970) and THE PATENTS RULES, 2003 APPLICATION FOR GRANT OF PATENT (See section 7, 54 and 135 and sub-rule (1) of rule 20)	(FOR OFFICE USE ONLY)

	Application No.	202531108913
	Filing date:	10-NOV-2025
	Amount of Fee paid:	
	CBR No:	
	Signature:	
1. APPLICANT'S REFERENCE / IDENTIFICATION NO. (AS ALLOTTED BY OFFICE)		

2. TYPE OF APPLICATION *Please tick (✓) at the appropriate category+

Ordinary (✓)		Convention ( )		PCT-NP ( )	
Divisional ( )	Patent of Addition ( )	Divisional ( )	Patent of Addition ( )	Divisional ( )	Patent of Addition ( )

3A. APPLICANT(S)

Name in Full	Nationality	Country of Residence	Address of the Applicant	
SRJX RESEARCH AND INNOVATION LAB LLP	**INDIAN**	**INDIA**	House No.	**PLOT NO.-3E/474 SECTOR-9, CDA**
			Street	**POST- MARKAT NAGAR, AVINAB BIDANASI**
			City	**CUTTACK**
			State	**ODISHA**
			Country	**INDIA**
			Pin code	**753014**

3B. CATEGORY OF APPLICANT *Please tick (✓) at the appropriate category+

Natural Person ()	Other than Natural Person (✓)		
	Small Entity ( )	Startup (✓)	Others ()

4. INVENTOR(S) *Please tick (✓) at the appropriate category+

Are all the inventor(s) same as the applicant(s) Named above?	Yes ()	No (✓)

If "No", furnish the details of the inventor(s)

Name in Full	Nationality	Country of Residence	Address of the Inventor	
JENA, Soumya Ranjan	**INDIAN**	**INDIA**	House No.	**PLOT NO.-3E/474 SECTOR-9, CDA**
			Street	**POST- MARKAT NAGAR, AVINAB BIDANASI**
			City	**CUTTACK**
			State	**ODISHA**
			Country	**INDIA**
			Pin code	**753014**
SAHA, Sanjoy	**INDIAN**	**INDIA**	House No.	**63/1,THAKUR PARA ROAD, P.O.- NAIHATI, NORTH 24 PARGANAS, WEST-BENGAL-743165, INDIA**
AGARWAL, Sohit	**INDIAN**	**INDIA**	House No.	**D 388, SARVANAND MARG, MALVIYA NAGAR, JAIPUR-302017, RAJASTHAN INDIA**

5. TITLE OF THE INVENTION: **AI BASED SMART STANDING FAN**

6. AUTHORISED REGISTERED PATENT AGENT(S)	Patent Agent No.	**1514**
	Name	**ANURADHA GUPTA**
	Mobile No.	**9213764385**
7. ADDRESS FOR SERVICE OF APPLICANT IN INDIA	Name	**S G INTELLECTUAL**
	Postal Address	**4-D (UPPER FLOOR), DDA POCKET-2 SECTOR-6, DWARKA, NEW DELHI-110075, DELHI**
	Telephone No.	**011 35586108**
	Mobile No.	**9213764385**

	E-mail ID	sav@sgintellectual.com

8. IN CASE OF APPLICATION CLAIMING PRIORITY OF APPLICATION FILED IN CONVENTION COUNTRY, PARTICULARS OF CONVENTION APPLICATION

Country	Application Number	Filing date	Name of the applicant	Title of the Invention
-------	------	---------------	-----------	-------------

9. IN CASE OF PCT NATIONAL PHASE APPLICATION, PARTICULARS OF INTERNATIONAL APPLICATION FILED UNDER PATENT CO-OPERATION TREATY (PCT)

International application number	International filing date
---------------------------	-----------------------

10. IN CASE OF DIVISIONAL APPLICATION FILED UNDER SECTION 16, PARTICULARS OF ORIGINAL (FIRST) APPLICATION-NA

Original (first) application No	Date of filing of original (first) application
--------------------------	---------------------

11. IN CASE OF PATENT OF ADDITION FILED UNDER SECTION 54, PARTICULARS OF MAIN APPLICATION OR PATENT-NA

Main application/patent No.--------------	Date of filing of main application ----------------

12. DECLARATIONS

(i) Declaration by the inventor(s)-
(In case the applicant is an assignee: the inventor(s) may sign herein below or the applicant may upload the assignment or enclose the assignment with this application for patent or send the assignment by post/electronic transmission duly authenticated within the prescribed period).

We, the above named inventors are the true & first inventors for this Invention and declare that the applicant herein is our assignee ~~or legal representative~~.

i) (a) Date: 10-NOV-2025

(b) Signature: Soumya Ranjan Jena

(c) Name : **JENA, Soumya Ranjan**

ii) (a) Date: 10-NOV-2025

(b) Signature: Sanjoy Saha

(c) Name: **SAHA, Sanjoy**

iii) (a) Date: 10-NOV-2025

(b) Signature: Sohit Agarwal

(c) Name: **AGARWAL, Sohit**

ii) Declaration by the applicant(s) in the convention country ---N/A

(In case the applicant in India is different than the applicant in the convention country: the applicant in the convention country may sign herein below or applicant in India may upload the assignment from the applicant in the convention country or enclose the said assignment with this application for patent or send the assignment by post/electronic transmission duly authenticated within the prescribed period)

I/We, the applicant(s) in the convention country declare that the applicant(s) herein is/are my/our assignee or legal representative.

(a) Date

(b) Signature(s)

(c) Name(s)

(iii) Declaration by the applicant(s)

- I/We the applicant(s) hereby declare(s) that: -
- I am/ We are in possession of the above-mentioned invention.
- The Complete Specification relating to the invention is filed with this Application.
- The invention as disclosed in the specification uses the biological material from India and the necessary permission from the competent authority shall be submitted by me/us before the grant of patent to me/us.
- There is no lawful ground of objection(s) to the grant of the Patent to me/us.
- I am/we are the true & first inventor(s).
- I am/we are the assignee or legal representative of true & first inventor(s).
- The application or each of the applications, particulars of which are given in Paragraph-8, was the first application in convention country/countries in respect of my/our invention(s).
- I/We claim the priority from the above-mentioned application(s) filed in convention country/countries and state that no application for protection in respect of the invention had been made in a convention country before that date by me/us or by any person from which I/We derive the title.
- My/our application in India is based on international application under Patent Cooperation Treaty (PCT) as mentioned in Paragraph-9.
- The application is divided out of my /our application particulars of which is given in Paragraph-10 and pray that this application may be treated as deemed to have been filed on DD/MM/YYYY under section 16 of the Act.

13. FOLLOWING ARE THE ATTACHMENTS WITH THE APPLICATION

(a) Form 1

Item	Details	Fee	Remarks
Complete specification	No. of Pages - 29	Rs.5280/-	
Claim(s)	No. of Claims - 15 No. of Pages - 8	----------------	------------------
Abstract	No. of Pages - 01		
Drawing(s)-	No. of Drawings -5 No. of Pages -5		

(b) Complete Specification
(d) Drawings
(c) Abstract
(d) Application Form-1
(e) Power of Attorney
(f) DIPP Certificate.
(g) Form-28
(h) Form-18A

....

We hereby declare that to the best of our knowledge, information and belief, the fact and matters stated herein are correct and We request that a patent may be granted to us for the said invention.

Dated this 10th day of NOV 2025

Signature:

Soumya Ranjan Jena

(Dr. Soumya Ranjan Jena)
DIRECTOR
Name of Applicant: **SRJX RESEARCH AND INNOVATION LAB LLP**

SRJX Research and Innovation Lab LLP
LLPIN: ACO-1435

To
The Controller of Patents
The Patent Office, KOLKATA

FORM 18 A **THE PATENTS ACT,1970** **and THE PATENT RULES,2003** **REQUEST FOR EXPEDITED EXAMINATION OF APPLICATION FOR PATENT** **[See section 11B and Rule 24C]**	(FOR OFFICE USE ONLY) RQ. No.: Filing Date: Amount of fee Paid: CBR no: Signature:

1. **APPLICANT:**

(A) NAME: **SRJX RESEARCH AND INNOVATION LAB LLP**

(B) NATIONALITY: **Indian Company**

(C) ADDRESS: **PLOT No.-3E/474, SECTOR-9, CDA, POST- MARKAT NAGAR, AVINAB BIDANASI, CUTTACK- 753014, ODISHA, INDIA**

2. We, **SRJX RESEARCH AND INNOVATION LAB LLP** established at PLOT No-3E/474, SECTOR-9, CDA, POST- MARKAT NAGAR, AVINAB BIDANASI, CUTTACK- 753014, ODISHA, INDIA, hereby request that our Application Patent No. **202531108913** filed on 10-11-2025 for invention Titled "**AI BASED SMART STANDING FAN"** shall be examined under sections 12 and 13 of the Act.

~~or~~

~~I/We -- hereby request that my/our application for patent no.--------------- filed on -------------------- for -- the -- invention titled -- based on Patent Cooperation Treaty (PCT) application no………………..…. dated………………….. made in country ……….. shall be examined under sections 12 and 13 of the Act, immediately without waiting for the expiry of 31 months as specified in rule 20(4)(ii). or~~

~~I/We hereby request that my/our request for examination bearing no.------------ for application for patent no.--------------- filed on -------------------- for ------------------------------------ the -- invention titled ------------------------------------ may be converted to a request for expedited examination of patent application under rule 24C and the application shall be examined under sections 12 and 13 of the Act.~~

3. The applicant(s) to indicate (by ticking the appropriate box) any of the grounds applicable for request for expedited examination:

() that India has been indicated as the competent International Searching Authority or elected as an International Preliminary Examining Authority in the corresponding international application; or

(✓) that the applicant is a startup; or

( ) that the applicant is a small entity; or

( ) that the applicant is a natural person or in the case of joint applicants, all the applicants are natural persons, then applicant or at least one of the applicants is a female; or

( ) that the applicant is a department of the Government; or

( ) that the applicant is an institution established by a Central, Provincial or state Act, which is owned or controlled by the Government; or

( ) that the applicant is a Government company as defined in clause (45) of section 2 of the Companies Act, 2013 (18 of 2013); or

( ) that the applicant is an institution wholly or substantially financed by the Government; or

( ) that the application pertains to a sector which has been notified by the Central Government, on the basis of a request from the head of department of the Central Government; or

( ) that the applicant is eligible under an arrangement for processing a patent applicant pursuant to an agreement between Indian Patent Office and a foreign Patent Office.

ADDRESS FOR SERVICE IN INDIA:

ANURADHA GUPTA
4-D (UPPER FLOOR), DDA Flat, Pocket-2, Sector-6, Dwarka, New Delhi-110075, India
Mobile No. +91 9213764385
Email: sav@sgintellectual.com ; anuradha_sgi@yahoo.in

Dated this 11th day of November, 2025

Signature
-Digitally Signed-

Name of the signatory: **Anuradha Gupta**
Agent for the Applicant
IN/PA-1514

To
The Controller of Patent
The Patent Office, at Kolkata

FORM 3

THE PATENT ACT, 1970

(39 of 1970)

and

THE PATENTS RULES, 2003

STATEMENT AND UNDERTAKING UNDER SECTION 3

(See Section 8; Rule 12)

1. Name of Applicant

I/We, **SRJX RESEARCH AND INNOVATION LAB LLP** established at PLOT No-3E/474, SECTOR-9, CDA, POST- MARKAT NAGAR, AVINAB BIDANASI, CUTTACK- 753014, ODISHA, INDIA,
Hereby Declare:

(i) That I/We who have made the application for Patent number 202531108913 in India, dated 10th November 2025 alone

(ii) that I/We have not made any application for the same/substantially the same invention outside India

Or

(ii) ~~that I/We have made for the same/substantially same invention, application(s) for patent in the other countries, the particular of which are given below:~~

Name of the Country	Date of application	Application No.	Status of the application	Date of publication	Date of grant
---------	-------	NIL	----------	-----------	-------------

2. Name and address of the assignee

~~(i) that the rights in the application(s) filed in India has/have been assigned to……………………….~~

(ii) that I/We undertake that upto the date of grant of the patent by the Controller, I/We would keep him informed in writing regarding the details of corresponding applications for patents filed outside India in accordance with the provisions contained in section 8 and rule 12.

Dated this 11th day of November 2025.

3. To be signed by the applicant or his authorized registered patent agent

Signature

4. Name of the Natural person who has signed

(**Anuradha Gupta)**
Patent Agent (IN/PA-1514)
Agent for the Applicant

To
The Controller of Patents,
The Patent Office
At Kolkata

FORM 9
THE PATENTS ACT, 1970
(39 of 1970)
&
The Patents Rules, 2003
REQUEST FOR PUBLICATION
[See section 11A (2); Rule 24A]

1. Name, address and nationality of Applicant(s)	We, **SRJX RESEARCH AND INNOVATION LAB LLP** a Company registered in India, having office at PLOT No.- 3E/474, SECTOR-9, CDA, POST- MARKAT NAGAR, AVINAB BIDANASI, CUTTACK- 753014, ODISHA India,
2. To be signed by the applicant or his authorized registered patent agent	**hereby** request for early publication of our Patent Application No. **202531108913 dated 10th November 2025** under section 11A (2) of the Patent Act.

.

Dated this 11th day of November 2025

3. Name of the natural person who has signed.	-Digitally Signed- (Anuradha Gupta) Patent Agent (IN/PA-1514) Agent for the Applicant

To
The Controller of Patents,
The Patent Office,
At KOLKAT

<table>
<tr><td colspan="3">FORMS 28
THE PATENTS ACT, 1970
(39 of 1970)
AND
THE PATENTS RULES, 2003
TO BE SUBMITTED BY A SMALL ENTITY / STARTUP
[See rules 2 (fa), 2(fb) and 7]</td></tr>
<tr><td>1.</td><td>Insert name, address and nationality</td><td>We, SRJX RESEARCH AND INNOVATION LAB LLP, a company registered in India, having office at PLOT NO.-3E/474, SECTOR-9, CDA, POST- MARKAT NAGAR, AVINAB BIDANASI, CUTTACK-753014, ODISHA, INDIA
Applicant in respect of the patent application No. 202531108913
Hereby declare that we are a startup in accordance with rule 2(fb) and submit the following documents(s) as proof:</td></tr>
<tr><td>2.</td><td colspan="2">Documents to be submitted</td></tr>
<tr><td></td><td colspan="2">ii. For claiming the status of a startup</td></tr>
<tr><td></td><td colspan="2">A. For an Indian applicant: Any document as evidence of eligibility, as defined in rule 2(fb).</td></tr>
<tr><td></td><td colspan="2">Certificate of Recognition issued by DIPP: Certificate No. DIPP203406</td></tr>
<tr><td>3.</td><td>To be signed by the applicant(s) / patentee(s) / authorized registered patent agent.</td><td rowspan="2">The information provided herein is correct to the best of our knowledge and belief.

Dated this 11th day of November 2025.

Signature :

-Digitally Signed-
(Anuradha Gupta)
Patent Agent (IN/PA-1514)
Agent for the Applicant
To
The Controller of Patents,
The Patent Office,
At Kolkata.</td></tr>
<tr><td>4.</td><td>Name of the natural person who has signed. Designation and official seal, if any, of the person who has signed.</td></tr>
</table>

CERTIFICATE NO:
DIPP203406

सत्यमेव जयते
Government of India
Ministry of Commerce & Industry
Department for Promotion of Industry and Internal Trade

#startupindia

CERTIFICATE OF RECOGNITION

*This is to certify that **SRJX RESEARCH AND INNOVATION LAB LLP** incorporated as a **Limited Liability Partnership** on **05-05-2025**, is recognized as a startup by the Department for Promotion of Industry and Internal Trade. The startup is working in 'Professional & Commercial Services' Industry and 'Professional Information Services' sector as self-certified by them.*

This certificate shall only be valid for the Entity up to **Ten** years from the date of its incorporation only if its turnover for any of the financial years has not extended **₹ 100 Cr.**

14-05-2025
DATE OF ISSUE

Scan to Verify

04-05-2035
VALID UPTO

सत्यमेव जयते

INDIA NON JUDICIAL

Government of National Capital Territory of Delhi

₹100

e-Stamp

Certificate No.	:	IN-DL90166275229451X
Certificate Issued Date	:	08-Nov-2025 06:21 PM
Account Reference	:	SELFPRINT (PU)/ dl-self/ NEHRU/ DL-DLH
Unique Doc. Reference	:	SUBIN-DLDL-SELF08300131237176X
Purchased by	:	SATYA NARAYAN SAV
Description of Document	:	Article 48(c) Power of attorney - GPA
Property Description	:	FILING OF PATENT APPLICATION BY SRJX RESEARCH AND INNOVATION LAB LLP
Consideration Price (Rs.)	:	0 (Zero)
First Party	:	SRJX RESEARCH AND INNOVATION LAB LLP
Second Party	:	S N SAV AND ANURADHA GUPTA
Stamp Duty Paid By	:	SRJX RESEARCH AND INNOVATION LAB LLP
Stamp Duty Amount(Rs.)	:	100 (One Hundred only)

₹100

SELF PRINTED CERTIFICATE TO BE VERIFIED BY THE RECIPIENT AT WWW.SHCILESTAMP.COM

IN-DL90166275229451X

Please write or type below this line

FORM 26

THE PATENTS ACT, 1970

(39 of 1970)

&

THE PATENTS RULES, 2003

Form of authorization of a patent agent/or any person in a matter or proceeding under the Act
(See sections 127 and 132 and rule 135)

We,

SRJX RESEARCH AND INNOVATION LAB LLP, a company registered in India, having office at **PLOT NO-3E/474, SECTOR-9, CDA, POST- MARKAT NAGAR, AVINAB BIDANASI, CUTTACK- 753014, ODISHA, INDIA,**

do hereby authorize **S. N. Sav and Anuradha Gupta**, Patent Agent of **S G Intellectual**, 4-D (UPPER FLOOR), DDA Pocket-2, Sector-6, Dwarka, **New Delhi**-110075, and also at A-108, Block-A, MBR Shangri La, Mysore Road, Kengeri, **Bangalore**-560059, India and/or all or any Associates/ Partners of the firm, to act on our behalf in connection with the filing Patent application for the invention titled "**AI BASED SMART STANDING FAN**" with the Controller of Patents, appearing on our behalf before the Controller, processing our application in respect of the same, filing provisional and/or complete specifications, and other necessary request and documents in connection with **the grant of Patent for the above application**, obtaining certified copies/extracts from the Patent Office, Certificate/s of Registration, filing request for renewal of the Patent and generally to do all acts, deeds and things that may be necessary in connection with the above application, including appointment of any substitute or substitutes.

We request that all notices, requisitions and communication relating thereto may be sent to such person at the above address unless otherwise specified.

We hereby revoke all our previous authorization, if any made, in respect of same matter or proceeding.

We hereby assent to the action already taken by the above said person in the matter.

Dated this 8th day of NOV **2025**

Soumya Ranjan Jena

(Dr. Soumya Ranjan Jena)
Designation: Director
SRJX RESEARCH AND INNOVATION LAB LLP

SRJX Research and Innovation Lab LLP
LLPIN: ACO-1435

To,
The Controller of Patents,
Patent Office, Kolkata