IoT-Enabled Smart Desk & Chair System

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ABSTRACT – Individual user preferences for the indoor environment can be learned by the smart desk, which can then customize the space according to those preferences and serve as an intelligent support system to increase user comfort, productivity, and health. We outline the general framework for the smart desk and provide a brief overview of recent developments in various fields that can be used to improve occupant experience in buildings. We discuss potential directions for future research as we wrap up the paper. The human body frequently engages in sitting in daily life. In literature, it has been discovered that bad sitting postures can cause discomfort and other issues. In this paper, we have designed a highly practical smart chair system that can accurately and non-invasively monitor human sitting behavior in order to prevent the negative effects of poor sitting behavior. In order to automatically recognize eight standardized sitting postures of human subjects using an artificial neural network classifier, the pressure patterns of these postures were recorded and sent to the computer. According to the results of the experiment, it can accurately identify eight different sitting positions of people. The smart chair system's built-in sitting posture monitoring feature can prevent or lessen the chronic diseases brought on by bad sitting habits while also assisting or encouraging people to adopt and maintain healthy sitting habits. These encouraging findings implied that the suggested system is workable for tracking sitting behavior, which has uses in a variety of fields such as intelligent environments, healthcare services, and human-computer interactions.

Keywords: Internet of Things (IoT), smart desk, classification, smart chair, and sitting behavior.

1. INTRODUCTION

Numerous factors, such as shifts in the nature of work, digitization, the incorporation of ergonomics into space design, the expense of constructing and maintaining office spaces, and the desire to increase employee productivity, have contributed to the evolution of the office workplace over the past few decades. Workspaces changed over time, for instance, from open-floor factories in the 1920s to individual cubicles in the 1980s to more adaptable and cooperative areas in the 21st century. The design and arrangement of the office workstation (desk, chair, and partitioning furniture), which has evolved over time from supporting paperwork to supporting

personal computers, is at the heart of the evolution of the workspace. The office desk is becoming an interactive device that supports various inputs, including touch, hand gestures, and voice commands, thanks to recent developments in Human–Computer Interaction (HCI). This facilitates improved collaboration, quicker information retrieval, and less paperwork. One of the most common positions that people adopt in their daily lives is sitting. People sit in lounge chairs, car seats, and office chairs for extended periods of time. Analysis of sitting behavior has recently gained attention in a number of fields, including facility design, public healthcare services, and biomedical engineering. Poor sitting habits have been linked to a number of pains and other issues, which may pose a threat to human health. According to earlier research, certain typical sitting positions can cause lumbar flexion and increased compressive forces in the lumbar joints. Real-time monitoring of sitting posture has drawn special attention and has been employed as a promising technique in recent years to prevent the negative effects of poor sitting behavior. The pressure distribution measurement sheets that are positioned on the seat pan and backrest have been used in research studies to provide high-resolution pressure data for posture recognition. Our project's long-term objective is to create an interactive ergonomic chair and a monitoring system for both static and dynamic sitting postures.

2. LITERATURE SURVEY

The goal of research on IoT-enabled smart desk and chair systems is to improve user productivity and well-being by integrating and connecting sensors. To detect prolonged sitting, monitor posture, and occasionally track physiological parameters like heart rate, smart chairs use motion, pressure, and textile sensors. Feedback systems that encourage better sitting habits include haptic alerts and mobile notifications. Automatic height adjustment is a common feature of smart desks that encourage sit-stand habits. Additionally, they can incorporate environmental sensors to track temperature, light, and air quality. Common features include connectivity with other smart devices, integrated charging, and usage analytics. The research shows that ergonomic and customized workspaces are becoming more and more popular. By providing insights into user behavior and workspace optimization, the data gathered by these systems opens the door to more effective and healthy work environments. Future research is expected to focus on advanced sensor integration, seamless connectivity, and AI-driven personalization.

3. WORKING PRINCIPLE

For increased functionality, smart desks make use of sensors, actuators, and a microcontroller. Electric motors and linear actuators that react to user input or preset schedules are used to adjust height. The microcontroller receives information from sensors that measure temperature, light levels, and desk occupancy. Bluetooth or Wi-Fi connectivity enables communication with mobile apps and user devices. Through these interfaces, users can view environmental data, adjust settings, and control desk height. Certain smart desks can learn user preferences to make adjustments automatically and provide information about usage patterns, like how much

time is spent standing and sitting. As the main processing unit, the microcontroller interprets sensor data and manages the desk's features to maximize user comfort and efficiency. A variety of built-in sensors are used by smart chairs to track a user's posture, amount of time spent sitting, and occasionally even physiological parameters. Real-time posture feedback is provided by pressure sensors built into the seat and backrest that measure spinal alignment and weight distribution. Accelerometers or sensors based on textiles can be used to further examine sitting and movement patterns.

The information gathered by these sensors is processed by a microcontroller. This data is then frequently sent wirelessly (via Wi-Fi or Bluetooth) to a computer or mobile application that is connected. The app gives users information about how they sit, warns them when they sit for extended periods of time, and may even offer tailored suggestions for better posture. Some sophisticated smart chairs use vibrations, or haptic feedback, to gently remind users to correct their posture. Additionally, they may interface with other intelligent systems or gadgets.

Fig. 1. 3-D SolidWorks Model

4. COMPONENTS

Hardware Components:

1.Caster(wheel): - Casters are small wheels attached to the bottom of chair legs, enabling easy movement across various floor surfaces. They are a fundamental component in office and task chairs, enhancing mobility and flexibility within workspaces. The main parts of a caster include the mount (which attaches to the chair), the wheel (which rolls on the floor), and the stem (which connects the wheel to the chair leg). There are several types of casters, such as plate mount casters where a flat plate is fixed to the chair leg and stem casters, which use a cylindrical stem inserted into the leg. The wheels themselves are made from materials like nylon, elastomers, plastic, rubber, or metal, depending on the intended use and weight requirements. Office chair casters are often made from plastic or rubber for smooth rolling and to prevent floor damage, while heavy-duty industrial casters use metal for greater durability.

2. Gas lift cylinder: - The gas lift cylinder, also known as a pneumatic or hydraulic cylinder, is a vital component responsible for the height adjustment in office chairs. It consists of a steel cylindrical tube housing a piston and a chamber filled with compressed gas, typically nitrogen. When the user activates the adjustment lever, a valve opens, allowing the gas to expand or compress, which moves the piston and raises or lowers the seat.

3. Chair Mechanism: - The chair mechanism is the assembly beneath the seat that integrates various adjustment controls, such as tilt, recline, and sometimes seat depth. It connects the seat plate to the gas lift cylinder and allows the user to customize their sitting experience for comfort and ergonomics.

25 Key features of chair mechanisms include:

• Tilt Tension: Adjusts the resistance when reclining, allowing users to control how easily the chair rocks backward.

• Tilt Lock: Locks the chair in an upright or reclined position, useful for different tasks.

• Seat Height Adjustment: Works in conjunction with the gas lift cylinder to raise or lower the seat.

• Swivel Function: Enables 360-degree rotation for easy movement and access to different areas of the workspace.

4. Arm Rest: Armrests are components attached to the sides of chairs, providing a place for users to rest their arms. They are found in a wide range of seating, from office and gaming chairs to automobiles and sofas. In office chairs, armrests can be fixed or adjustable, with the latter allowing users to modify height, width, and angle for optimal ergonomic support. The primary function of armrests is to reduce strain on the shoulders and upper body, promoting better posture and comfort during prolonged sitting. In some designs, armrests may also include additional features such as cup holders, storage compartments, or integrated controls for added convenience. Properly adjusted armrests help prevent musculoskeletal discomfort and enhance overall seating ergonomics.

6. Back Rest: - The backrest frame is the structural backbone of the chair's back support. It is usually constructed from metal or reinforced plastic to provide strength and durability. The frame supports the backrest cushion or mesh, ensuring it maintains its shape and provides adequate support to the user's spine. Ergonomic backrest frames are designed to follow the natural curvature of the spine, offering lumbar support and promoting healthy posture. Some backrests are height-adjustable or feature flexible sections to accommodate different users. The backrest frame is crucial for preventing back pain and fatigue, especially during long hours of sitting.

7. Head Rest: A headrest is an extension of the backrest, positioned to support the user's head and neck. It is a common feature in ergonomic office chairs, gaming chairs, and vehicle seats. Headrests can be fixed or adjustable in height and angle, allowing users to tailor the support to their needs.The primary purpose of a headrest is to reduce strain on the neck and shoulders, particularly during extended periods of sitting. Ergonomic headrests are often made from cushioned or mesh materials, providing comfort while maintaining breathability. By supporting the head and neck, headrests help prevent tension headaches and musculoskeletal issues.

In some advanced designs, the headrest is integrated with the backrest for seamless support and adjustability.

8. PIR Sensor: Passive infrared (PIR) sensor is an electronic sensor that detects infrared (IR) light emitted by objects within its view. They are used most often in PIR motion detectors. PIR sensors are widely used in security alarm and automatic lighting systems. A PIR-based motion detector is used to sense movement of people, animals, or other objects. They are commonly used in burglar alarms and automatically activated lighting systems.

9. Planet Geared Motor: -

DC planetary gear motors are effective for delivering a high torque-to-size ratio, accuracy, and motion control in compressed space that make them ideal for industrial use. DC planetary gear motors come in a variety of sizes, torque ratings, and configurations. Planetary gearing finds application in rugged applications because the three planet gears are evenly distributed around the sun gear. They are stronger and power dense in that they support higher torques and reductions within a smaller, more compact package.

10. Lead Screw: - A leadscrew (or lead screw), or power screw or translation screw, is a screw serving as a machine linkage, to convert turning motion into linear motion. Due to the great sliding contact area between their male and female members, screw threads are subject to higher frictional energy losses than other linkages. They are not generally employed to transmit high power, but rather for infrequent use in low power actuator and positioner mechanisms. Leadscrews are found in linear actuators, machine slides (e.g., in machine tools), vises, presses, and jacks. Leadscrews are a standard element in electric linear actuators.

11. Internal and External Rod: - The inner rod in a square table is a structural element installed inside the table framework, not usually exposed on the outside. It serves a major purpose in offering inner support and stability to the general structure of the table. The interior rod is used to reinforce the internal structure of the square table. It bridges various components of the table—like the legs, top plate, or pillars—and keeps the table firm in shape, balance, and rigidity. It is particularly critical to avoid wobbling or collapsing under pressure or weight.

Wooden Ply: - Wooden ply, also referred to as plywood, is an artificial engineered wood that is created through the process of laminating thin wood veneer layers (or "plies") together. The veneers are piled upon each other with their wood grain alternating (typically at 90 degrees) to one another. This cross-graining method provides strength, stability, and warp resistance for plywood.

4. ADVANTAGE AND APPLICATION

Smart Desk

Advantages:

- Improved Health: Encourages movement (sit-stand), reduces back pain and sedentary behavior risks.
- Increased Productivity: Enhances focus and energy levels through adjustable and comfortable workspaces.
- Ergonomics & Comfort: Customizable height and settings promote better posture.
- Enhanced Organization: Integrated charging and cable management reduce clutter.
- Data Insights: Tracks usage patterns for workspace optimization.

Applications:

- Offices: Creating dynamic and healthy work environments.
- Home Offices: Promoting well-being and productivity for remote workers.
- Educational Institutions: Providing adaptable learning spaces.
- Healthcare: Ergonomic workstations for practitioners and adaptable patient areas.
- Industrial Settings: Adjustable benches for varied tasks and operator comfort.

Smart Chair

Advantages:

- Posture Correction: Detects and alerts users about poor sitting habits.
- Health Monitoring: Tracks sitting time and may monitor physiological data.
- Reduced Health Risks: Mitigates issues related to prolonged sitting and bad posture.
- Personalized Comfort: Some offer automated ergonomic adjustments.
- Data-Driven Wellness: Provides insights into sitting behavior for health improvement.

Applications:

- Offices: Promoting ergonomic seating and employee well-being.
- Home Use: Cultivating healthy sitting habits during work or leisure.
- Healthcare: Monitoring patient posture and rehabilitation progress.
- Vehicles: Enhancing driver's comfort and safety through posture support.
- Educational Institutions: Supporting proper posture for students.

CONCLUSIONS

An important step toward designing workspaces that are healthier, more comfortable, and more productive is the implementation of IoT-enabled smart desk and chair systems. They provide real-time feedback and automation for sit-stand exercises, posture correction, and environmental adjustments by combining sensors and connectivity. The information gathered offers insightful information for improving workspace efficiency and personal well-being. The trend points to a future in which intelligent furniture will be essential in fostering user efficiency and well-being in a variety of contexts, including homes and workplaces, even though the field is still developing.

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