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DESIGN AND IMPLEMENTATION OF AN ERGONOMIC MODULAR DESK WITH ELECTRIC CONTROL

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Abstract: *This paper presents the conceptual design and theoretical development of a modular, ergonomic desk system equipped with electric adjustment mechanisms. The primary objective is to create a workspace solution that optimizes user posture, enhances productivity, and minimizes the adverse health effects associated with prolonged sitting. The desk is designed to adapt to the user's height, thereby alleviating pressure on the lumbar and cervical regions of the spine. This adjustment mechanism promotes better ergonomics and reduces strain, catering to individual physical needs and preferences.*
Furthermore, this study serves as the foundation for developing a comprehensive smart desk system. The proposed desk integrates advanced technologies, such as motorized adjustment systems and modular components, enabling seamless transitions between different working configurations. These features not only improve physical comfort but also enhance workflow efficiency by allowing users to focus on their tasks without interruptions caused by manual adjustments.
The paper also outlines the theoretical aspects involved in designing such a system, including load distribution analysis, motor sizing calculations, and structural integrity assessments. These theoretical frameworks ensure that the desk's functionality and safety are optimized for a wide range of use cases.
By addressing both ergonomic and technological challenges, this work lays the groundwork for future advancements in smart furniture design. The modularity and adaptability of the desk also make it a sustainable and future-proof solution, capable of incorporating emerging technologies like IoT and AI for real-time ergonomic monitoring and adjustments.

Key words: Smart, Desk, Health, Productivity

1. INTRODUCTION

In today's rapidly digitalizing and interconnected world, smart desks symbolize a significant leap in workspace evolution, addressing the dynamic needs of modern users and organizations. These innovative workstations merge advanced technologies, such as Internet of Things (IoT), Artificial Intelligence (AI), and automation systems, to create environments that are not only efficient and productive but also prioritize user comfort and well-being. The success of designing a smart desk hinges on a deep understanding of user requirements and the strategic application of these technologies to fulfill diverse needs. [1], [2].
Smart desks go beyond traditional furniture, incorporating technologies like IoT sensors to monitor and adjust environmental factors such as lighting, temperature, and even posture-related metrics. AI-driven systems provide real-time feedback and recommendations to users, helping maintain ergonomic postures and adapt workspaces dynamically throughout the day. Automation enhances the desk's functionality by enabling seamless transitions between different configurations, such as switching from sitting to standing modes [3], [5], [6].

The benefits of smart desks extend far beyond convenience. Operational efficiency is achieved through automation and optimization of processes, leading to measurable time and cost savings. For instance,

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intelligent memory settings allow multiple users to save and recall their preferred configurations with minimal effort, reducing setup times and enhancing shared workspace utility [3], [6], [9].

Additionally, the ability to adjust desks to suit individual needs contributes to a reduction in workplace fatigue and musculoskeletal disorders, directly impacting productivity and long-term health [7], [8].

From an organizational perspective, smart desks align with sustainable design principles. The integration of energy-efficient motors and materials ensures minimal environmental impact. Moreover, modularity allows for scalability and future-proofing, enabling upgrades such as IoT-enabled data collection systems that monitor workspace utilization and employee interaction patterns. This data-driven approach supports informed decision-making to optimize space allocation and enhance the overall work environment [1], [4], [10].

As a cornerstone of modern workspace innovation, smart desks represent a convergence of ergonomic design and cutting-edge technology. They offer a glimpse into the future of workspaces, where adaptability, efficiency, and sustainability form the foundation of productivity and employee satisfaction. The challenge, however, lies in balancing the costs of these advanced systems with their long-term benefits, a factor that should guide their design and implementation strategy [2], [3], [7].

2. SIMILAR SYSTEMS IN THE MARKET

There are a few systems in the market that want to achieve similar goals, but while this study was performed, none of the existing products are as evolved as this one.

One of the similar products aiming to benefit the health of the individuals using it is made by a brand named Secretlabs. With their desk “Secretlabs Magnus PRO” they aim to enable the user to adjust the height of the desk. However, that product does not help enabling a user switch easy. For example, if the product is installed in a home with two people, the memory function implemented by the Secretlabs team only allows the height of the legs to be memorized. In this way, the other user needs to adjust the height of the monitors manually.[3]

Figure 1: Secretlabs Magnus PRO [3]

3. THEORETICAL ASPECTS CONCERNING THE CALCULATIONS REQUIRED FOR DESK DESIGN

3.1. Masses in the system

For each mechanism calculations for the masses of the object moved needed to be made. So, for that, the masses were calculated based on the density and volume of each part in the system.

Input data:

- Density of wood (oak) (ρ) = 700 kg/m³;
- Density of aluminum (ρ) = 2700 kg/m³;
- Density of steel GCr15 (52100) (ρ) = 7810 kg/m³;

In this way, all the masses were calculated:

- Total mass supported by the legs = 435 kg;
- Total mass supported by the computing unit = 22.77 kg;
- Total mass supported by the top tabletop = 17.98 kg;
- Total mass supported by the bottom tabletop = 15.47 kg;
- Total mass supported by the stage 2 monitor stand = 14.58 kg;
- Total mass supported by the stage 1 monitor stand = 36.11 kg;

3.2. Motor’s Sizing

First of all, these will be taken into account:

- F_f = frictional force;
- N = normal to the surface;
- F_i = inertial force;
- G = weight;
- p = step;

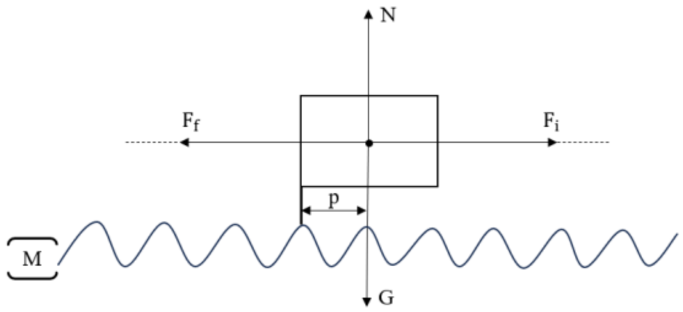

Figure 2: The distribution of forces acting on the orizontal axis

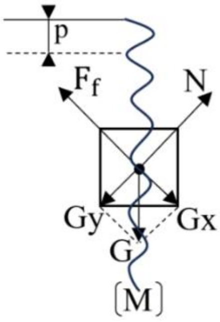

Figure 3: The distribution of forces acting on the vertical axis

Due to the fact that everything is in motion, the acceleration was determined, and in order to determine the reaction force exerted on a body, the product of the total mass and gravitational acceleration was calculated. With the help of these, the inertia force, frictional force, and resultant force were determined as follows:

Table 1: The mathematical calculations of the forces involved in each system

	a [m/s^2]	G [N]	F_i [N]	F_f [N]	F_r [N]
Motor sizing for the leg lifting systems	1	2133.67	435	64.01	2669.68
Motor sizing for the computing unit lifting system	1	111.68	22.77	3.35	137.80
Motor sizing for the top tabletop motion system	1	88.19	17.98	2.64	20.62
Motor sizing for the bottom tabletop motion system	1	75.88	15.47	2.27	17.74
Motor sizing for the second monitor stage lifting system	1	71.22	14.58	2.13	87.93
Motor sizing for the first monitor stage lifting system	1	177.11	36.11	5.31	218.54

As a result of the calculation performed, it is possible to determine the extent to which the body resist changes to its state of rest or uniform rotational motion under the action of a torque. Thus, the motor torque and the moment of inertia of the screw were calculated. With these values, the required torque to set each motor in motion was established, also considering a potential load applied to the system by the user, and therefore a safety factor is taken into account. To determine the number of rotations performed in one minute, the rotational speed (RPM) will be calculated. [4]

Table 2: The mathematical calculations of the necessary torque and RPM of the motors

	M_m [N·m]	M_i [N·m]	M_{mt}+ fs [N·m]	n $[rot/min]$
Motor sizing for the leg lifting systems	4.24	0.0028	6.37	127.35
Motor sizing for the computing unit lifting system	0.21	0.0037	0.44	127.35
Motor sizing for the top tabletop motion system	0.03	0.0028	0.05	127.35

Motor sizing for the bottom tabletop motion system	0.02	0.0028	0.04	127.35
Motor sizing for the second monitor stage lifting system	0.14	0.0022	0.21	127.35
Motor sizing for the first monitor stage lifting system	0.34	0.0029	0.52	127.35

4. THE TRIDIMENSIONAL DESIGN CONCEPT

4.1. Design of the leg lifting system assembly

For the assembly modeling, the process started with creating the plates that will form the frames. Thus, two such frames were created, equipped with access spaces for mounting the motors and the ball screws of the tabletops [5]. To increase the safety and stability of the frames, two legs were designed, which will be assembled at the back of the main frame.

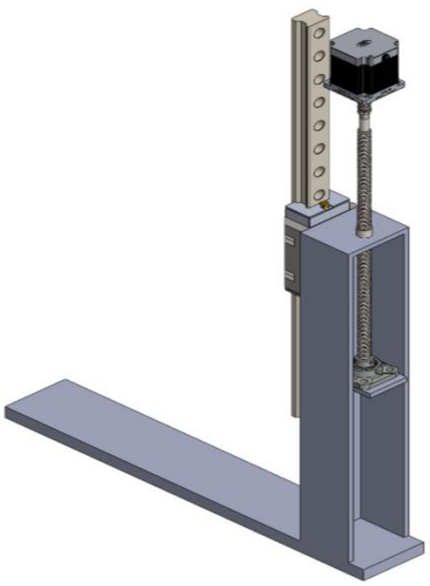

Figure 2: Design concept of the leg

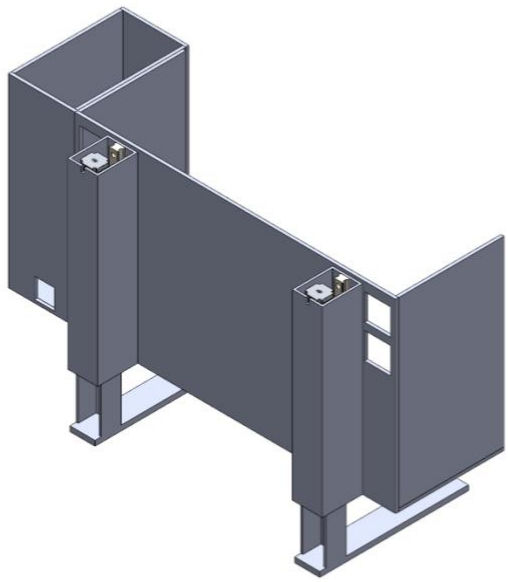

Figure 3: Design concept of the leg assembly

4.2. Design concept of the monitor lifting system assembly

To bring the monitors to the desired height, two lifting monitor stages were implemented. These stages are designed in series to maximize the height that monitors can achieve. The first stage is designed to raise the monitors as high as possible, while the second stage allows for more precise adjustment according to the user's preferences.

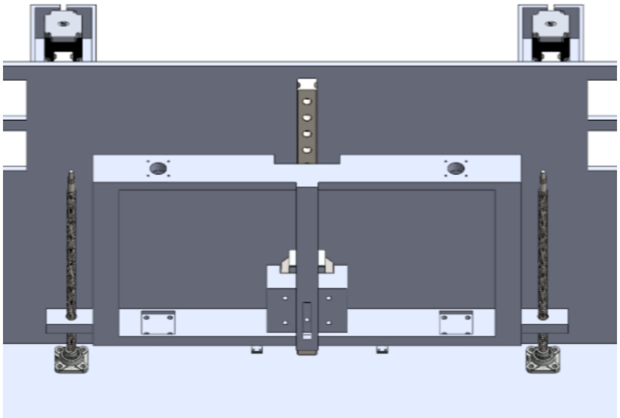

Figure 6: Design concept of the monitor lift system

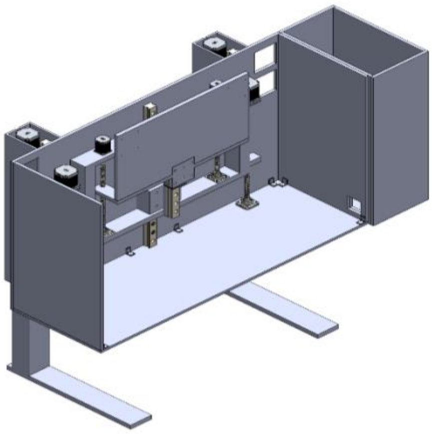

Figure 7: Design concept of the monitor system assembly

4.3. Design concept of the tabletop motion systems

When it comes to the tabletops, it was necessary to implement two such systems. The upper system is intended to create storage space as well as serve an aesthetic purpose while retracted (not in use), while the lower system supports the mouse and keyboard.

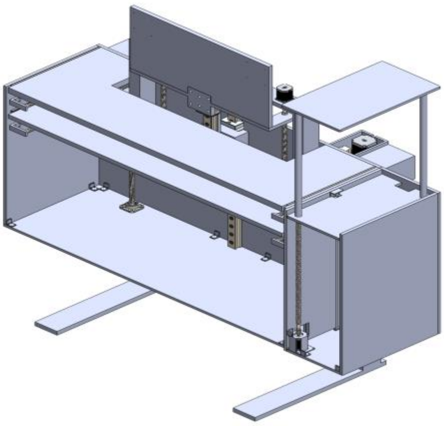

Figure 8: Design of the tabletops

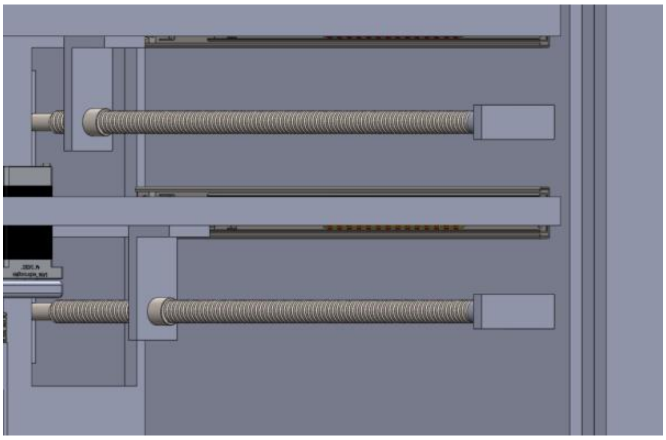

Figure 9: Design of the ballscrew mechanism for the tabletops

4.4. Design concept of the computing unit lifting system

The lift for the computing unit serves two purposes: firstly, it enhances the desk's aesthetics by minimizing the space it occupies when not in use, as it can be concealed; secondly, it provides a storage surface on top of the lift.

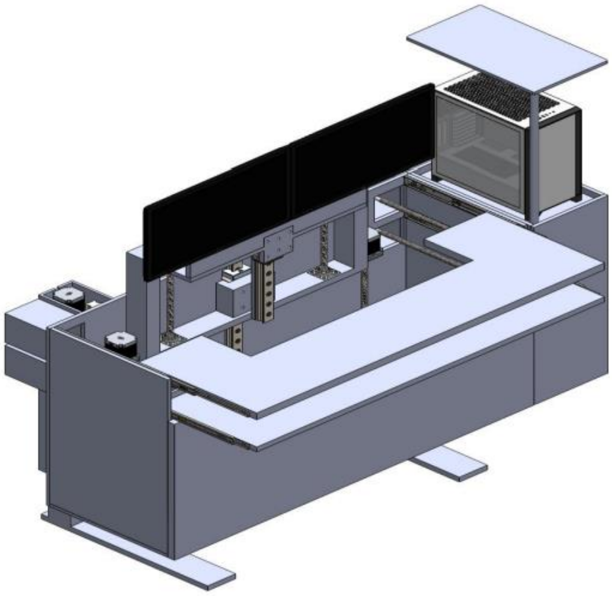

Figure 4: Complete assembly

5. CONCLUSION

This study focuses on the design and implementation of a modular ergonomic desk equipped with electric adjustment systems, offering a highly customizable solution for modern users. The primary goal of the project was to improve user posture, ensuring a healthy and correct alignment for various body types and working needs. To achieve this, the desk includes height-adjustable features that allow users to position their legs comfortably while seated. Furthermore, the monitors can be easily raised or lowered at the push of a button, promoting proper neck posture and reducing strain.

The proposed desk goes beyond standard ergonomics by integrating advanced functionalities and a thoughtful design. Its modular structure allows for individual customization, catering to the specific needs of each user. The stability of the frame and the precision of the ball screw mechanisms ensure both safety and durability, while the motorized adjustments provide effortless and reliable operation.

This innovative approach not only prioritizes health and comfort but also enhances productivity by enabling seamless transitions between different working positions. The desk's adaptability accommodates a range of professional environments, from home offices to corporate settings, making it a versatile and future-proof solution.

Moreover, the modular nature of the desk ensures scalability, allowing for future upgrades, such as IoT integration or intelligent systems for real-time ergonomic adjustments. This forward-thinking design philosophy positions the desk as not just a functional piece of furniture but as a cornerstone of modern, dynamic workspaces.

By addressing the challenges of static postures and designing for flexibility, this project sets a new standard in ergonomic furniture. Future studies may explore the inclusion of smart technologies and data-driven solutions to further optimize user experience and workplace efficiency.

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