Automatic Self-Folding Dining Table

1. Introduction

The demand for space-saving furniture solutions has increased with the growing need for multi-functional living spaces, especially in urban environments where space is limited. Our project aims to address this need by designing a dining table that can automatically fold and unfold, optimizing space usage when the table is not in use. This project integrates a servo motor with an Arduino system, enabling the table to fold itself with the press of a button. The system ensures ease of use, efficiency, and space optimization, making it a practical solution for homes, apartments, and offices where space is at a premium.

The mechanism utilizes a servo motor, which is controlled by the Arduino setup. A simple switch allows the user to initiate the folding or unfolding process, while the servo motor controls the movement of the table. The use of automation minimizes the need for manual effort, adding convenience and comfort for users. This self-folding mechanism provides a seamless transition from a functional dining table to a compact form, making it ideal for dynamic and adaptive spaces.

2. Need Analysis

In contemporary living spaces, especially in smaller homes and apartments, efficient utilization of available space has become crucial. Dining tables, while essential, can occupy significant space, making them inconvenient in multi-functional spaces. The idea of an automatic self-folding dining table arises from the need for furniture that can be transformed or adjusted without requiring excessive manual effort.

Manual folding tables often require physical strength and time, which can be an inconvenience for people with limited mobility or for those who desire a more streamlined solution. Additionally, the need for flexibility in modern interiors demands furniture that can quickly adapt to changing requirements. An automated solution that can reduce the effort needed to transform the table would make it a highly attractive option for a variety of settings, including small homes, apartments, cafes, or offices.

The use of a servo motor and Arduino setup in this project allows for easy and efficient control of the folding mechanism, providing an automated, hands-free solution to space-saving. The integration of modern technology into everyday furniture ensures both functional and aesthetic benefits. This project not only meets the practical needs of space optimization but also introduces an innovative approach to the design and use of domestic furniture

3. Design specifications

The design specifications for the **Automatic Self-Folding Dining Table** are as follows:

- **Table Dimensions:**
  - **Height:** 9 in
  - **Width:** 9 in
  - **Length:** 10.5 in
- **Side Plate Dimensions:** 9in x 9in

Initially, we designed the table with larger dimensions of 60 cm x 50 cm x 60 cm, aiming to provide a more spacious dining area. However, during the design process, we faced challenges in sourcing a motor that could provide the high torque and force necessary to operate the table at these dimensions. The larger size and weight of the table required a motor with substantial power, but suitable motors within our budget proved difficult to find.

To address this issue, we decided to reduce the dimensions of the table. By downsizing, we were able to select a more affordable motor with the required torque and force to operate the folding mechanism effectively. This modification ensures that the system remains both functional and cost-efficient, while still offering the space-saving benefits and ease of use intended in the original design.

First Draft of table

4. Analysis and/or selection rationale of the machine elements and components

Initially, we faced several challenges related to the motor selection and the overall design, but through careful analysis and adjustment, we arrived at the best solution for our project.

1. **Initial Motor Selection: NEMA 17 Stepper Motor**

At the start, we designed the table with larger dimensions (60 cm x 50 cm x 60 cm) and needed a motor with enough torque to handle the weight of the table while folding and unfolding. Based on our calculations, we estimated that a motor with around 0.7 Nm of torque would be necessary.

We initially chose a **NEMA 17 stepper motor** because of its high torque output and ability to provide precise control over the table's movements.

Why We Chose It:

- **High Torque**: The NEMA 17 stepper motor was selected because it could theoretically provide the torque needed to move the larger table.
- **Precision**: Stepper motors offer precise control, which was important for ensuring the table folds correctly without any jerky movements.

Challenges:

- After testing, we realized that our torque calculation didn't factor in a safety margin, which meant the NEMA 17 motor was underperforming. The motor struggled to handle the load of the larger table, and we didn't get the desired results.

2. **Revised Table Size and New Motor Selection**

After encountering issues with the NEMA 17 stepper motor, we decided to reduce the size of the table. By making the table smaller, we could use a motor that required less torque, which also helped solve the problem of finding a motor that would fit within our budget.

Why We Made the Change:

- **Easier to Handle**: Reducing the table size allowed us to rethink the motor requirements and made it easier to find a suitable motor that could perform effectively with the new dimensions.

- **Improved Efficiency**: The smaller table required less force to fold and unfold, making the entire mechanism easier to design and implement.

3. **Final Motor Selection: Servo Motor**

   With the table now smaller, we switched to a **servo motor**. Servo motors are commonly used in applications where precise movements are needed, and they are compact and cost-effective, which made them a perfect fit for this project.

   Why We Chose the Servo Motor:

   - **Sufficient Torque**: The servo motor we selected had enough torque to handle the weight of the smaller table and control the folding mechanism.
   - **Simpler Control**: Servos are easy to control with Arduino, and they offer smooth and reliable movement, which was essential for the automatic folding function.
   - **Space and Integration**: Servo motors are compact and fit well within the design constraints of our table, ensuring that the folding mechanism could be implemented without additional complexity.

4. **Support Structure Inside the Table**

   In the original design, we planned to incorporate an internal support structure to stabilize the table in the **unfolded state**. The idea was that after the side panels of the table folded upwards, a support would automatically engage to hold the table securely in its open position. This was necessary because the servo motor alone could not provide sufficient holding torque to maintain the table in the unfolded state.

   Why We Wanted the Support:

   - **Added Stability:** The support structure was designed to stabilize the table when fully unfolded, preventing it from collapsing or tipping over due to insufficient motor torque.
   - **Automatic Engagement:** This system would have engaged automatically as the side panels reached the unfolded position, eliminating the need for manual adjustments and ensuring a seamless operation.

   Challenges:

   - **Time Constraints:** Due to the limited time available for project completion, we couldn’t fully implement the support mechanism as intended.
   - **Material Sourcing Issues:** Finding suitable materials and components to build the support structure within our timeline proved challenging.

   While the support structure was not included in the final prototype, it remains a crucial feature for future iterations to enhance the table’s stability and functionality in the unfolded state.

5. **Arduino and L293D Motor Driver**

To control the servo motor, we used an **Arduino microcontroller** along with the **L293D motor driver**. Arduino provided a simple and flexible platform to program and control the motor, while the L293D motor driver allowed us to handle the motor's power requirements.

Why We Chose Arduino and L293D:

- **Ease of Control**: Arduino is user-friendly and compatible with various components, making it ideal for controlling the servo motor and ensuring smooth operation of the folding mechanism.
- **Motor Driver Compatibility**: The L293D motor driver is designed to work well with small motors, and it allows us to efficiently control the servo motor's movement.

5. Synthesis and integration of components: Solid models of the components and the full assembly

Our project was developed through careful planning and hands-on assembly of its key components. The integration process involved selecting appropriate elements, testing their compatibility, and ensuring that they worked together seamlessly to achieve the desired functionality.

Design and Selection of Components

1. **Table Panels**:
    - The table's main structure included a central panel and two foldable side panels. These were designed with practical dimensions to make the folding and unfolding process smooth and efficient.
    - Hinges were used to connect the panels, allowing for smooth rotational movement.
2. **Servo Motor and Linkage**:
    - After reducing the table's dimensions, we selected a servo motor to operate the folding mechanism. The motor was chosen for its ability to provide sufficient torque to lift and lower the side panels of the smaller table.
    - A simple mechanical linkage was used to transfer the motor's movement to the side panels. This linkage ensured accurate and consistent folding and unfolding.
3. **Support Structure (Planned but Not Implemented)**:

- We envisioned a support structure to stabilize the table when fully unfolded, as the servo motor alone could not hold the table's weight in that position.
    - This support was designed to automatically engage when the side panels were lifted, providing additional strength. Unfortunately, due to time constraints, this feature was not included in the final prototype but remains a planned improvement.
4. **Frame and Hinges**:
    - The table frame was constructed to provide stability and house all components securely.
    - The hinges connecting the panels were selected to ensure durability and allow for smooth folding.
5. **Electronics Setup**:
    - The Arduino microcontroller and L293D motor driver were used to control the servo motor.
    - A switch was connected to the Arduino for user input, enabling easy operation of the folding mechanism.

Integration and Assembly Process

1. **Component Selection**: Each component was chosen based on its functionality, cost, and compatibility with other elements of the system.
2. **Prototyping and Testing**: Components were tested individually and in combination to ensure proper operation. Adjustments were made to improve alignment and performance.
3. **Final Assembly**: All elements were integrated into the table's frame, with careful attention to positioning and connections. The servo motor was connected to the panels via the linkage, and the electronics were securely housed to maintain reliability during operation.

Challenges and Adjustments

- **Torque Issues**: Initially, the larger table dimensions required a high-torque motor, which was beyond our budget. This led to the decision to reduce the table's size and switch to a servo motor.
- **Support Mechanism**: The lack of a support structure in the final prototype meant the servo motor carried most of the load. This highlighted the need for an additional stabilizing mechanism in future iterations.
- **Manual Adjustments**: Without advanced tools for simulation or modeling, the integration process relied heavily on manual adjustments and testing. This approach, while time-consuming, helped identify and resolve practical issues effectively.

Conclusion

The synthesis and integration of components were carried out systematically, using a practical and hands-on approach. While the project achieved its goal of creating a functional self-folding dining table, there is room for further improvement, such as adding a support structure for stability and optimizing the overall mechanism.

6. Manufacturing drawings, bill of materials, cost analysis

6.1 Manufacturing Drawings

Detailed drawings of all components were prepared with dimensions and tolerances to aid fabrication.

6.2 Bill of Materials (BOM)

Component	Cost (Rs)
NEMA 17 Stepper Motor	600
Arduino Uno	600
L293D Motor Driver	180
Push Button	20
Cable	50
Jumper wires	30
Switch	10
Ion Cell	150
9V battery	30
Wood and wheels	2600
Total Cost	**Rs 4270**

6.3 Cost Analysis

The total project cost was Rs 4270. This includes the cost of servo motor, arduino, stepper motor, jumper wires, battery, power cell, wood, hinges and wheels. Low-cost prototyping materials were used (e.g., plywood), and automation parts like the stepper motor and Arduino Uno provided sufficient performance for testing.

7. Final product specifications and images

7.1 Final Specifications

Parameter	Specification
Table Dimensions	9in x 10.5in x 9in
Material	Plywood for table panels
Folding Mechanism	Servo motor-driven system
Control System	Arduino Uno with push-button input
Power source	Battery cell
Mobility	Attached wheels for easy transportation

Key Functionalities

- **Folding and Unfolding**: The servo motor smoothly folds and unfolds the table's side panels upon activating the push button.
- **Compact Design**: The table can be folded into a compact size, making it ideal for small spaces.
- **Stable Base**: The structure ensures stability when folded or unfolded, with a sturdy wooden frame.

7.2 Images of the Final Product

Folded state

Unfolded state

Inner structure

8. Summary and highlights of the project

This project successfully developed a compact, semi-automatic folding table that combines mechanical and electronic systems. Despite challenges like torque limitations and budget constraints, the team adapted by resizing the table and switching to a servo motor.

Key highlights:

- Integration of Arduino-controlled servo motor for smooth folding and unfolding.

- Efficient use of materials, completing the prototype within Rs. 4270.
- A focus on space-saving design with potential for future enhancements, such as an automatic support mechanism for stability.

The work demonstrated innovative problem-solving and practical engineering skills, delivering a functional prototype with scope for further refinement.

9. Statement outlining the contribution of each member of the team

Name	Roll Number	Contribution	Percentage (%)
Kavan Vavadiya	210100166	Conceptualizing, Hardware Setup, Designing, report writing	50
Aniruddh Goyal	210100014	Hardware Setup, Designing, report writing	15
Anish Kumar Sahu	210100015	Hardware Setup	14
Ishaan Abhyankar	21D100008	presentation	6
Siddharth Farkiya	210100145	Table setup	6
Akanksha Kadam	210100007	Slide preparing	6
Arham Jain	210100023	Attending meets	1.5
Prasad Chaure	210100047	Attending meets	1.5

Thank you!