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Evaluating the Performance of an Arduino-Controlled Wood Scaling Machine

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Abstract*— The aim of this quantitative study was to evaluate the performance of an Arduino-controlled wood scaling machine, designed to improve the cutting process for woodwork and furniture production. The machine was developed with the goal of achieving accuracy, precision, and consistency in wood cutting, while also reducing the need for time-consuming grinding and polishing. The wood cutter machine was composed of a circular saw, relay, conveyor, and control module, with the added feature of an Arduino for automated scaling. The study found that the machine's performance was more reliable, effective, and safer than other wood cutting machines, and its use could lead to faster, better, and more accurate cuts. The wood scale cutter machine was also designed to be more affordable while maintaining a standard quality that would ensure its longevity for years. The results of this study offer an innovative and improved wood cutting tool that could compete in the market and benefit workers by reducing working time and increasing productivity.

Keywords*— Table saw, wood cutter machine, Arduino, automated scaling tool, wood scale cutter

I. INTRODUCTION

Wood is a fibrous material obtained from trees, which has been a fundamental tool for centuries. It has multiple applications, such as DIY projects, furniture making, and more. However, cutting wood can be challenging, and table saws are the most common tool used for this purpose. In modern times, advancements in technology have led to safer, more convenient, and efficient ways of cutting wood, with the table saw being the top choice for many. Despite this, the accuracy and precision of wood cutting machines can still be a problem, and researcher are continually exploring new methods and technologies to improve them. Manufacturing has been a significant driving force for economic growth since the 19th century, and technology has played a crucial role in this development. The woodworking industry has evolved tremendously, with digital tools and innovations leading the way. The emphasis is now on producing accurate and precise wood cutting machines that are cost-effective and reduce waste.

One particular wood cutting machine that has gained popularity is the Wood Scale Cutter Machine Using Arduino. This machine uses an automated scaling system that ensures accuracy, precision, and safety while working with wood. It has several benefits, including being a time-efficient and hassle-free tool for woodworkers. The most recent requirements in machine tools are their accuracy and precision. Then they have found out that most of the researcher focus on designing a machine that uses the process of Statistical and comparative methods that improves the proven design of a sawmill that practically has similar kinematics, design, and sizes by improving its spindle that regulates the operations(Orlowski, et al., 2020). To improve safety while using wood cutting machines, researcher have explored the use of sensor-based safety systems to prevent accidents. Moreover, some studies have focused on developing logical control systems and algorithms to automate wood cutting processes, such as the Feed Mechanism Control Model for KARA Master Circular Saw Based on SWITCH Technology(Shifrin, et al., 2020). Technology has played a significant role in the

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development of wood cutting machines, and innovations like the Wood Scale Cutter Machine Using Arduino have made woodcutting safer, more efficient, and cost-effective. researcher continue to explore new methods and technologies to improve wood cutting machines' accuracy and precision, making them more reliable and sustainable in the long run.

II. PROTOTYPE AND TESTING

Figure 1 illustrates the machine development and prototype from various perspectives to provide a better understanding of its design and optimal functionality. The system is built upon components such as Arduino, washing motors, screw-type conveyor relays, push buttons, limit switches, miniature circuit breakers, and an LCD. The process starts with loading a piece of wood onto the conveyor. The wood conveyor then moves the plank forward towards the wood cutter, where it is cut to the desired size. Subsequently, the wood cutter and conveyor both reverse their motions. It is crucial to reset the system before initiating another cutting process.

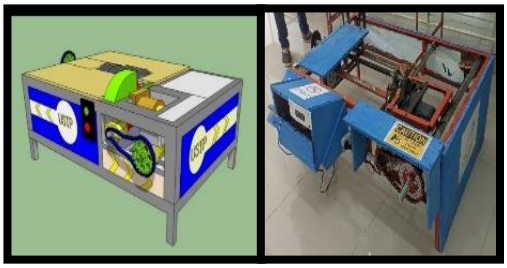

Figure 1 Right side view of the Machine and Prototype

During the testing procedure, the following steps were executed to ensure the LCD functions correctly and displays the input sizes accurately. The LCD shows the input sizes corresponding to the push buttons pressed. For instance, when the push button for 1 foot, 1.5 feet, or 2 feet is pressed, the LCD displays "1ft, 1.5ft, or 2ft cutting" accordingly. The conveyor and circular saw operate efficiently, and the operator demonstrates cutting 1 foot, 1.5 feet, and 2 feet sizes individually. It is essential to note that the given sizes yield an approximate output size. Once the cutting is completed, the LCD displays "CUT IS DONE". This process is repeated 2 to 3 times for accuracy and reliability. For intermittent cutting, the LCD shows "intermittent cutting", and the conveyor and circular saw function effectively. The operator demonstrates cutting a 3-inch size piece of wood multiple times. It is crucial to observe that the given size results in an approximate output size. Once the cutting is finished, the LCD displays "CUT IS DONE", similar to the regular cutting process. The procedure is repeated 2 to 3 times for accuracy and reliability. The output is depicted in Figure 2.

Figure 2 Output of the Intermittent Cutting

III. RESULTS AND DISCUSSIONS

To guarantee the efficacy and quality of the assembled prototype, a comprehensive evaluation was conducted. Well-defined and easily understandable survey questionnaires were distributed to gather feedback. Table 1 presents the rating scale used to assess various aspects of the product under evaluation. The table provides a level of agreement, corresponding mean scores, and weights for each category. The levels of agreement are divided into five categories: Excellent, Very Good, Good, Poor, and Very Poor. The mean scores range from 1.00 to 5.00, with each level of agreement having a specific score range. The weight column assigns numerical values from 1 to 5 for each level of agreement, with 1 being the lowest and 5 being the highest. This rating scale serves as a tool for quantifying the responses and measuring the performance of the product.

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Table 1 Rating scale

Level of agreement	Mean Score	Weight
Excellent	4.51- 5.00	5
Very Good	3.51- 4.50	4
Good	2.51- 3.50	3
Poor	1.51- 2.50	2
Very Poor	1.00- 1.50	1

The researcher examined the results and discussions derived from the collected data. Notably, the prototype differs slightly from the original design, as the researcher sought ways to reduce the budget, resulting in the adoption of DIY strategies. In the pursuit of improvement, a miniature cutter machine was utilized instead of a table-type cutter. However, the circular saw blade was insufficient for cutting at a 45-degree angle due to its limited radius, although it was suitable for miniature applications. To verify the product, the researcher presented data using a custom-made survey questionnaire.

Machine Test Results

The motor demonstrated efficient forward and reverse performance. The conveyor operated smoothly, stopping at the required sizes. The circular saw functioned well, providing precise cuts.

Software Test Results

All components programmed within the Arduino operated smoothly. The LCD accurately displayed input sizes, and the relays and push buttons functioned as intended. The researcher discussed the prototype evaluation, addressing the effectiveness, reliability, and efficiency of the developed Wood Scale Cutter Machine. The evaluation parameters included Prototype Functionality, Prototype Safety, Prototype Mobility, Prototype Marketability, and Prototype Aesthetics.

Prototype Functionality

Table 2 Mean Responses in terms of Functionality

FUNCTIONALITY	MEAN
1. The product I/O function well according to its uses.	4.80
2. The cutter cuts accurately and appropriately.	3.50
3. The Program configures well in the system.	4.70
4. The conveyor's and circular saws motor function well.	4.55
5. The overall, product function well.	4.85
Mean Average	4.48

Table 2 presents the mean responses of users evaluating a prototype product in terms of functionality. Five aspects of functionality are assessed, with the mean average score across all aspects being 4.48 out of a possible 5. This suggests that users generally perceive the prototype as functional and effective. Product I/O functionality (4.80/5): Users report that the product's input/output (I/O) functions work well according to their intended uses. This high score indicates that the product is effective in processing and handling data, which is crucial for its overall performance. Cutter accuracy (3.50/5): The cutter's accuracy and appropriateness receive a moderate rating from users, suggesting that there is room for improvement in this aspect of functionality. Enhancements to the cutter's design, materials, or calibration could lead to more precise cutting and improved

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user satisfaction. Program configuration (4.70/5): Users find that the program configures well within the system, indicating that the software component of the product is well-designed and integrates effectively with the hardware. This is essential for ensuring smooth operation and user experience. Conveyor and circular saw motor functionality (4.55/5): Users report that the motors for the conveyor and circular saw function well, suggesting that these components are reliable and efficient. This aspect contributes to the overall functionality and performance of the product. Overall product functionality (4.85/5): Users rate the overall functionality of the product very highly, indicating that it performs well as a complete system. This is a critical aspect, as a well-functioning product can drive customer satisfaction and positive word of mouth. Tthe prototype product is generally perceived as functional, with strong scores in I/O functionality, program configuration, motor functionality, and overall performance. The main area for improvement is the cutter's accuracy, which could be addressed through design or calibration enhancements. The prototype's functionality is promising, and with some adjustments, it could become even more effective in meeting user needs.

Prototype Safety

Table 3 Mean Responses in terms of Safety

SAFETY	MEAN
1. The installed components are securely fastened and tightened.	3.60
2. The wires were properly insulated.	3.95
3. The motors were protected well and secured.	3.65
4. The circular saw blade is well protected.	2.05
5. The Prototype safety and easily manipulated.	4.25
Mean Average	3.49

Table 3 presents the mean responses of users evaluating a prototype product in terms of safety. Five aspects of safety are assessed, with the mean average score across all aspects being 3.49 out of a possible 5. This suggests that users perceive the prototype's safety as moderate, and there are areas where improvements can be made. Securely fastened components (3.60/5): Users report that the installed components are somewhat securely fastened and tightened. There is room for improvement in this aspect of safety, which could be addressed by ensuring all components are firmly attached and secure to prevent accidents or malfunctions. Properly insulated wires (3.95/5): The product's wires are rated as moderately well insulated. While this score is not particularly low, improvements could be made to increase user confidence in the product's electrical safety, such as using higher-quality insulation materials or double-checking insulation during assembly. Motor protection (3.65/5): Users perceive the motors as fairly well protected and secured, but there is still room for improvement. Enhancing motor enclosures or implementing additional safety features could increase user confidence in the product's safety. Circular saw blade protection (2.05/5): The circular saw blade's protection receives a low score, indicating a significant area for improvement. Implementing better safety features, such as a more robust blade guard, an automatic brake system, or additional safety warnings, could greatly enhance the product's safety in this aspect. Prototype safety and manipulation (4.25/5): Users rate the prototype as relatively safe and easily manipulated. This is a positive aspect of the product's safety, as it indicates that users feel confident in operating the product and can do so with ease. The prototype product's safety is perceived as moderate, with the most significant area for improvement being the circular saw blade protection. Addressing this issue and making minor improvements to component fastening, wire insulation, and motor protection could greatly enhance the overall safety of the product. A safer product would likely increase user confidence and satisfaction, as well as minimize potential liabilities.

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Prototype Mobility

Table 4 Mean Responses in terms of Mobility

MOBILITY	MEAN
1. The product is lightweight.	3.75
2. The Product is easy to carry.	3.25
3. The product can be moved from one place to the other place.	4.90
4. The product is hassle-free.	3.75
5. The component is removable without affecting the other component.	4.75
Mean Average	4.08

Table 4 presents the mean responses of users evaluating a prototype product in terms of mobility. Five aspects of mobility are assessed, with the mean average score across all aspects being 4.08 out of a possible 5. This suggests that users generally perceive the prototype as a mobile product. Lightweight (3.75/5): Users find the product relatively lightweight, although there is room for improvement to increase the overall perception of mobility. Easy to carry (3.25/5): The product's ease of carrying is moderately rated by the users. This suggests potential enhancements could be made to improve the product's portability, such as incorporating handles, reducing size or weight, or providing a carrying case. Easy to move from one place to another (4.90/5): This aspect of mobility received the highest score, indicating that users find the product very easy to move from one location to another. The high score suggests that the product's design facilitates easy relocation, which is a critical aspect of mobility. Hassle-free (3.75/5): Users report the product to be relatively hassle-free, but there is still room for improvement. Optimizing the design to minimize setup, disassembly, or adjustment time could lead to an even more hassle-free experience. Removable components without affecting others (4.75/5): Users find the components can be easily removed without impacting the other components, suggesting a modular design that allows for customization or easier transportation. This is a strong feature of the product's mobility. The prototype product is generally perceived as mobile, with the strongest aspects being easy movement between locations and removable components. Improvements could be made to increase the perception of mobility, such as reducing weight, optimizing carrying methods, and further reducing hassle.

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Prototype Marketability

Table 5 Mean Responses in terms of Marketability

Marketability	MEAN
1. The component is /are available in the market.	4.35
2 .The components is/ are readily made.	4.55
3. The components is/ are Affordable.	3.70
4. The Product is cost-efficient.	4.75
5. The product is competitive in this modern world.	4.80
Mean Average	4.43

Table 5 presents the mean responses of users evaluating a prototype product in terms of marketability. Five aspects of marketability are assessed, with the mean average score across all aspects being 4.43 out of a possible 5. This suggests that users generally perceive the prototype as marketable. Component availability (4.35/5): Users find that the product's components are largely available in the market. This is a positive aspect, as it indicates that sourcing the necessary parts for manufacturing should be relatively straightforward. Component readiness (4.55/5): Users believe that the components are readily made, suggesting that the prototype's design uses standardized, easy-to-produce parts. This can help streamline the manufacturing process and lower

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production costs. Component affordability (3.70/5): Users consider the components to be moderately affordable. While this is a decent score, there is room for improvement in terms of pricing. Identifying ways to source less expensive materials or negotiate better pricing with suppliers could increase the overall affordability of the components. Cost-efficiency (4.75/5): The product's cost-efficiency receives high marks from users. This indicates that the prototype offers a good balance between price and performance, providing value to potential customers. Competitiveness in the modern world (4.80/5): Users perceive the product as highly competitive in today's market. This is a strong indication that the product offers innovative features or a unique selling proposition that distinguishes it from competitors. In summary, the prototype product is generally perceived as marketable, with strong scores in component availability, readiness, cost-efficiency, and competitiveness. The main area for improvement is component affordability, which could be addressed through cost-saving measures in the supply chain. The prototype's marketability is promising, and with some adjustments, it could become even more appealing to potential customers.

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Prototype Aesthetics

Table 6 Mean Responses in terms of Aesthetics

AESTHETICS	MEAN
1. The product's design is suited.	4.65
2. The product choice of color is elegant to the viewer.	4.50
3. The labels are/are visible still visible at distance.	3.90
4. The components is /are well placed.	4.75
5. The product is acceptable.	4.75
Mean Average	4.51

Table 6 presents the mean responses of users evaluating a prototype product in terms of aesthetics. Five aspects of aesthetics are assessed, with the mean average score across all aspects being 4.51 out of a possible 5. This suggests that users generally perceive the prototype as aesthetically pleasing. Suited design (4.65/5): Users find the product's design to be well-suited, indicating that the overall form and layout of the product are appealing and functional. This is an essential aspect, as a suitable design can attract customers and improve user satisfaction. Elegant color choice (4.50/5): The product's choice of color is rated as elegant by users, suggesting that the colors used are visually appealing and contribute positively to the product's overall aesthetic. This can help create a strong visual identity for the product in the market. Label visibility (3.90/5): Users find the labels moderately visible from a distance, indicating that there is room for improvement in this aspect of aesthetics. Improving label visibility, through larger fonts, contrasting colors, or clearer design, can enhance the user experience and the overall aesthetic appeal of the product. Well-placed components (4.75/5): Users perceive the components to be well placed, which suggests that the product's layout and design are efficient and visually pleasing. This aspect contributes to the overall aesthetic appeal and can also influence the product's functionality and ease of use. Acceptability (4.75/5): The product's acceptability is rated highly by users, indicating that they find it visually appealing and would likely consider it for purchase. This is an important aspect of aesthetics, as an acceptable product can attract more customers and generate positive word of mouth. In summary, the prototype product is generally perceived as aesthetically pleasing, with strong scores in design suitability, color choice, component placement, and acceptability. The main area for improvement is label visibility, which could be addressed through design enhancements. The prototype's aesthetics are promising, and with some adjustments, it could become even more visually appealing to potential customers.

IV. CONCLUSIONS

The prototype product has received generally positive feedback across the four key aspects assessed: functionality, safety, aesthetics, and marketability. Users perceive the product as functional and effective, with high scores in I/O functionality, program configuration, motor functionality, and overall performance. However, improvements could be made to the cutter's accuracy, which may involve design or calibration enhancements.

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Safety is an area where the prototype requires more attention, particularly concerning the circular saw blade protection. Addressing this issue and making improvements to component fastening, wire insulation, and motor protection will greatly enhance the product's safety, increasing user confidence and satisfaction. The prototype is aesthetically pleasing, with strong scores in design suitability, color choice, component placement, and acceptability. To further improve its aesthetic appeal, enhancements could be made to label visibility through design adjustments. In terms of marketability, the prototype shows promise with high scores in component availability, readiness, cost-efficiency, and competitiveness. The main area for improvement is component affordability, which could be addressed through cost-saving measures in the supply chain. Hence, the prototype demonstrates significant potential, with some adjustments needed to enhance safety, aesthetics, and marketability. By addressing these areas, the product could become even more appealing to potential customers, leading to increased satisfaction and success in the market.

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