CircuitAssist: Automatically Dispensing Electronic Components to Facilitate Circuit Building

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CircuitAssist: Automatically Dispensing Electronic Components to Facilitate Circuit Building

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ABSTRACT

When learning how to build circuits, one of the challenges novice makers face is how to identify the components needed for the circuit. Many makerspaces are stocked with a variety of electronic components that look visually similar or have similar names. Thus, novice makers may pick the wrong component, which creates a non-functional circuit although the wires are correctly connected. To address this issue, we present CircuitAssist, an actuated electronics component shelf connected to a tutorial system that dispenses electronic components for the maker in the order that they occur in the tutorial. The shelf contains dispensers for each component type with a custom release mechanism actuated by a servo motor that dispenses one component at a time. Makers can work with CircuitAssist by either following one of the provided tutorials or by directly selecting a component they need from the user interface.

CCS CONCEPTS

• **Human-centered computing → Human computer interaction (HCI)**.

KEYWORDS

personal fabrication; circuit assembly; actuation; education

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1 INTRODUCTION

Over the last decade, makerspaces have become increasingly popular allowing a growing number of people to learn skills, such as electronics circuit building. An increasing number of learning resources, such as tutorials with step-by-step circuit building instructions, further support novice makers in mastering electronics.

To help novice makers improve their skills and avoid mistakes in their circuit, researchers have developed a range of support tools.

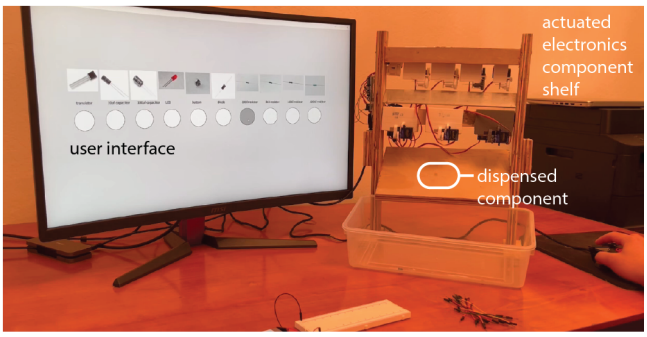

Figure 1: CircuitAssist is an actuated electronics components shelve that automatically dispenses electronic components in the order they occur in a tutorial.

For instance, CircuitStyle [1] helps makers improve their breadboard layout by showing best wiring practices and ToastBoard [2] supports makers by showing false wiring on the breadboard.

While these works support makers in wiring up the circuit, an earlier step that makers have to go through is to choose the correct components for the circuit. In makerspaces that are well stocked with a range of electronic components, there are hundreds of different parts that look similar and have similar names, which can lead to confusion. While systems, such as CurrentViz [6], inform a maker if a wrong component is plugged into the breadboard, it would be beneficial to prevent such mistakes in the first place by helping users identify the correct component ahead of time.

To address this issue, we present CircuitAssist, an actuated electronics component shelf that dispenses the correct components for the maker either based on the order they occur in a tutorial or based on the maker manually choosing components in a user interface. CircuitAssist supports makers in this first stage of circuit building, i.e. choosing the right components, and integrates well with existing tools, such as augmented breadboards, that support the later stages of wiring up the components on the breadboard.

2 RELATED WORK

Our work is related to systems that assist makers in electronics prototyping. One body of work has focused on augmenting digital user interfaces to help users plan circuit layouts. AutoFritz [4] auto-completes a maker's circuit wiring on a digital breadboard, while CircuitStyle [1] improves makers' circuit style by showing

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best practices. Since mistakes can also be introduced when physically building a circuit, augmented breadboards, such as ToastBoard [2] and CurrentViz [6], visualize where makers made mistakes. SchemaBoard [3] takes this a step further by assisting makers in translating abstract circuit schematics into breadboard component layouts by highlighting where components should be placed. Other projects, such as Proxino [5], support remote collaboration during circuit construction, which can help an experienced maker correct mistakes on a novice makers' breadboard. Our research complements these existing works by supporting novice makers in choosing the correct components for circuits.

3 CIRCUITASSIST

CircuitAssist is an actuated shelf that dispenses electronic components either based on the order they occur in a tutorial or the makers manual selection.

Hardware: CircuitAssist is a shelf that consists of an array of individually actuated dispensers. The dispensers are 3D printed (Ender3, PLA filament, 0.1mm) and contain electronic components stacked on top of each other in their main body (Figure 2a). The release mechanism consists of a set of gears connected to a servo motor (SG90) that actuates a rotating cylinder inside the dispenser (Figure 2b). The rotating cylinder is sized to allow for one component in it at a time. When the servo rotates the cylinder, the electronic component is dropped out of the dispenser. When the cylinder rotates back up a component from the dispenser's main body falls into the cylinder ready to be released upon the next actuation. The servo motors for all dispensers are connected to a microcontroller (Arduino Uno), which allows CircuitAssist's user interface to control which dispenser should release a component. Our prototype shelf currently contains 10 dispensers and is 38cm wide and 15cm high. The modular design of CircuitAssist allows makerspaces to easily expand the shelf with additional dispensers as needed.

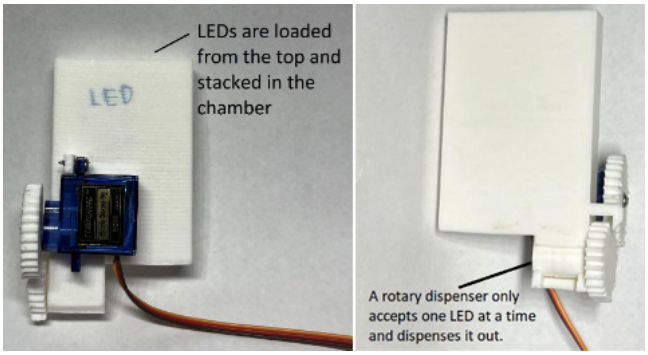

Figure 2: Dispenser Hardware Design.

Software: CircuitAssist's user interface (built in Processing) provides two modes of interaction: Makers can either choose to follow a tutorial, which releases the components according to the current tutorial step, or choose manual selection mode, which provides the user with a set of buttons to select components. When CircuitAssist determined that a component needs to be released, it sends a command to the microcontroller that contains the pin number that is connected to the corresponding dispenser's servo motor.

4 APPLICATION EXAMPLES

We built three tutorials to showcase CircuitAssist's functionality.

LED circuit: The first tutorial shows a novice maker how to build a circuit with an LED that lights up when a button is pressed. When the maker starts the tutorial the LED, a matching resistor, and a button are dispensed. We included this example since novice makers often confuse resistors with each other even when told the required resistance since they look similar. Choosing the wrong resistor either leads to a broken LED or an LED that does not light up, which can be frustrating. CircuitAssist prevents this mistake by dispensing the correct resistor for the maker.

Capacitor Delay Circuit: The second circuit builds on the first but also allows the LED to stay on for a while. When the button is pressed a capacitor charges and powers a transistor, completing the LED's circuit and lighting it up. After the button is released, the capacitor slowly drains through the 1k resistor. When it is drained, the transistor is no longer powered and the LED turns off. We included this example since it uses 2 resistors (one for the capacitor, one for the LED) of 2 different values (1k, 330ohm) which can easily be confused with each other. If the resistors are swapped in the circuit the LED would not stay on and not be as bright. CircuitAssist prevents this mistake by dispensing one resistor at a time, i.e. first the resistor for the capacitor, and then later the LED resistor.

LED Flasher: Our final circuit extends the previous circuit by flashing the LED on and off. To accomplish this, the circuit uses a second capacitor, which can be easily confused with the one used in the previous step. CircuitAssist prevents this mistake by dispensing the correct capacitor at the specific step in the tutorial.

5 DISCUSSION

We next discuss limitations and directions for future work.

Refilling Components: Our system requires the makerspace manager to restock the dispensers by inserting components one at a time, which takes more time than refilling a conventional shelve.

Number of Components: Our current system supports up to 10 different components. However, more dispensers can easily be added to the shelf since it is modular.

Integrating Existing Tutorials: For future work, we will interface with existing circuit building software, (e.g., Fritzing) to automatically dispense components based on digital breadboard layouts.

Tracking Number of Components: By counting how many components of each type have already been dispensed, our system can alert the makerspace manager to restock those components.

Potential to Improve Accessibility: While not the main focus of our work, our system might be helpful for makers with vision impairments who are not able to identify components visually.

6 CONCLUSION

We presented CircuitAssist, an actuated electronics component shelf that helps makers with their circuit building by dispensing the electronic components they need for their circuit. We discussed the hardware and software required to make CircuitAssist and showed how CircuitAssist can help at the example of three tutorials that contain components that can be easily confused by makers. Finally, we discussed limitations and future work of our approach, including CircuitAssist's scalability, connection to existing circuit building tutorials, and its potential application to improve accessibility.

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