Soft Circuits Toolkit

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A circuit-building kit that works on air

Project team
Catharina M. van Riet, Shibo Zou, Johannes T.B. Overvelde, and Frank L.M. Delbressine

Organization
AMOLF and Eindhoven University of Technology

Location
Amsterdam and Eindhoven, The Netherlands - Europe

Project type
Product, Methodology

PROJECT DESCRIPTION

The Soft Circuits Toolkit allows anyone to prototype fully soft circuits that work on air instead of electricity. The toolkit aims to interest youth in circuit-building, electronics, and engineering and inspire them to become the engineers of the future. The pneumatic circuits can be used to learn about how circuits work in general, but also to create playful and functional soft devices. Because these designs are fully soft and thus safer for humans to interact with, they show great potential in areas such as healthcare and human-robot interaction. The Soft Circuits Toolkit includes a range of components, including those that you normally find in analogue electronics kits. This allows anyone, but especially youth, to playfully and safely experiment with these pneumatic circuits and create their own soft designs.

CONTEXT AND HISTORY

This project started as a thesis research project in the Soft Robotic Matter group at AMOLF in Amsterdam, as part of the Industrial Design master's programme of Eindhoven University of Technology. The initial goal was to interest design and engineering students in soft robotics by giving them a ready-made toolkit for building soft, pneumatic circuits and projects. An additional goal of the project was to give soft robotics researchers a platform to quickly prototype soft circuits and integrate their own designs into this platform because of its modular nature.

During the early stages of prototyping, we discovered that this pneumatic circuit-building approach also lent itself well to teaching circuit-building in general to a wider audience, including secondary school students. As a result of this finding, the focus of the toolkit was shifted slightly, serving mainly as a teaching kit for circuit-building and soft robotics education in schools and universities.

WHAT IS THE NEED IT TACKLES?

In the Netherlands, rates of high school students obtaining a technical secondary school track have been steadily falling since 2017[1], despite personnel shortages rising in engineering fields[2]. This is concerning, especially as we are facing climate challenges that need future engineers to solve. The Dutch government therefore wants to inspire more youth to pursue an engineering career[3,4].

Our goal is to spark an early interest in engineering among the younger generation by providing a playful toolkit that teaches about engineering circuits. For very young audiences, we aim to use the toolkit to kindle the children's curiosity about how things work in general, promoting a lifelong interest in problem-solving and creation.
The toolkit also aims to foster critical thinking skills, preparing students for future studies in STEM fields. For students already taking an engineering degree, we aim to interest them in soft robotics and the design of soft devices in general.

WHAT WAS THE DEVELOPMENT PROCESS OF THE PROJECT LIKE?

Our process included early and frequent communication with the target group (secondary school and university students) to ensure that the toolkit fit their interests and needs. To better understand the target user group, initial informal interviews were conducted with secondary school students to gain a good understanding of their knowledge of pneumatic and electronic circuits. To create a soft, pneumatic circuit system, other circuit-building toolkits were analysed to design the circuit components. Expert feedback was gained through interviews from secondary school and university physics teachers. This feedback, combined with insights from user testing with university engineering students and secondary school students, was used to match the designs and educational materials to the needs and interests of the target user group.

IMAGE 1. *The Soft Circuits Toolkit. (1 August 2023. Eindhoven. Christ Clijsen.)*

A proof-of-concept toolkit was created that consisted of the physical toolkit and a manual with step-by-step circuit-building instructions. User testing was carried out with this first iteration that evaluated users' perceived self-efficacy in circuit-building before and after using the toolkit. Based on the insights gathered from these tests, further developments and improvements were incorporated, resulting in a second major iteration. An instructional website was also developed. Further user testing was carried out on this iteration, assessing user experience using a validated questionnaire (UEQ)[5], as well as evaluating the problem-solving potential of the toolkit through several circuit-building exercises designed to test basic circuit understanding.

IMAGE 2. *Overview of the circuit-building components included in the toolkit. (1 August 2023. Eindhoven. Christ Clijsen.)*

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WHAT IMPACT DOES YOUR PROJECT CURRENTLY HAVE?

Youth greatly enjoy playing with the toolkit and even creating their own circuits. They can understand the concept of airflow and apply it to the circuits they are building. Because they can feel the airflow and air pressure, they rapidly form an understanding of the circuits and components. Some students can even further apply this knowledge to building their own circuits. Additionally, because all the components are soft and use air instead of electricity, they are safe for interaction. At interactive demonstration events, children from the age of 5 were also able to work with the toolkit successfully. For these reasons, we expect the toolkit is also suitable for primary school children, and we are working on further testing with this target group.

We hope that the toolkit will inspire users to dive further into design, engineering, and soft robotics more specifically. As a designer, I personally feel that the toolkit is a great way to get a first taste of design that is soft and compliant. It shows that actuation can be achieved through pneumatics, with the design remaining soft in the process. Such an approach can have great potential in human-computer interaction for making robots that are safe and inviting for human interaction, or the design of assistive wearables such as support braces or pieces of clothing that have certain logic functions integrated while still remaining comfortable for the wearer. For designers and engineers, it could be fruitful to incorporate this approach to soft designs into their repertoire, so that they can broaden their design approaches.

WHAT IS THE GLOBAL-LOCAL RELATIONSHIP OF THE PROJECT?

Through our website, we show how anyone can build these pneumatic circuits and further expand on them by incorporating existing and newly designed components, as well as designing new types of circuits. In the future, we hope to offer a platform where these component and circuit designs can be shared. We have already included on the website and in the manual circuit designs contributed by users of the toolkit.

WHY IS THE SOFT CIRCUITS TOOLKIT DISTRIBUTED DESIGN?

One of the main goals of our project is to make it completely open source, so that anyone in the world can download the files and make their own toolkit, and even better, contribute their own designs to it. As a researcher, I feel strongly about making the results of publicly funded research publicly available. The first step in this process has been to create a website [QRcode 1]. that provides an in-depth look at how the toolkit functions.

However, we realise that not everyone has the capacity to fabricate this toolkit, so we are also looking at commercialisation of the toolkit to make it available to schools and interested individuals.

IF YOU COULD HAVE DINNER WITH ANYONE (HUMXN, PLANT, FUNGI, OR OTHERWISE) LIVING OR DEAD, WHO WOULD YOU DINE WITH?

Any dinosaur that would not have me for dinner. I would like to know what they actually looked like, if they had feathers, and if they were warm-blooded.

IMAGE 3. *The toolkit being tested by university students. (4 June 2023. Eindhoven. Katrien van Riet.)*

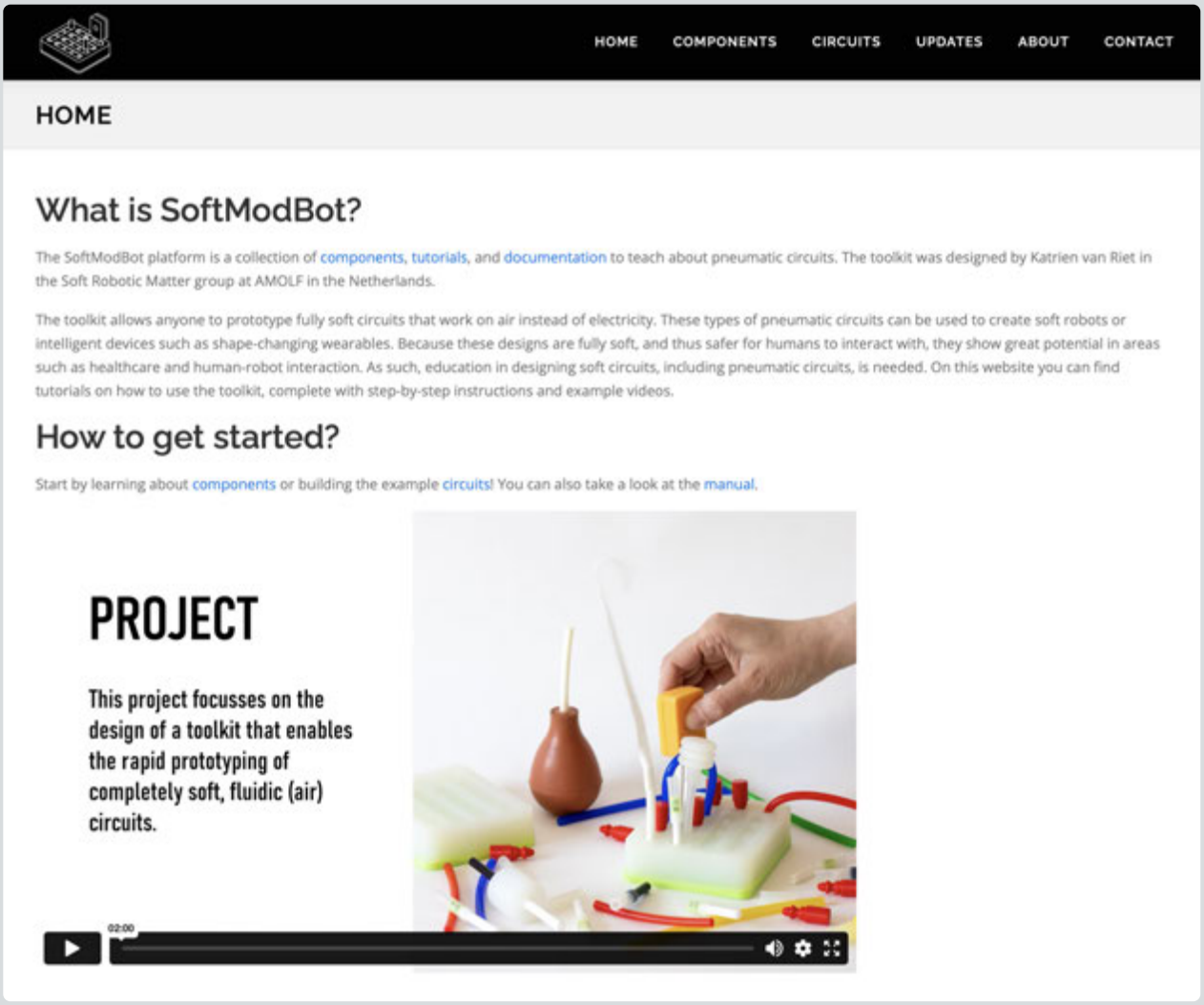

IMAGE 4. *The website that accompanies the toolkit, including example circuits, videos showing each circuit in action, information on all the components, and a pdf version of the manual. (30 December 2023. Utrecht. Katrien van Riet.)*

QR Code. Discover the Soft Circuit Toolkit