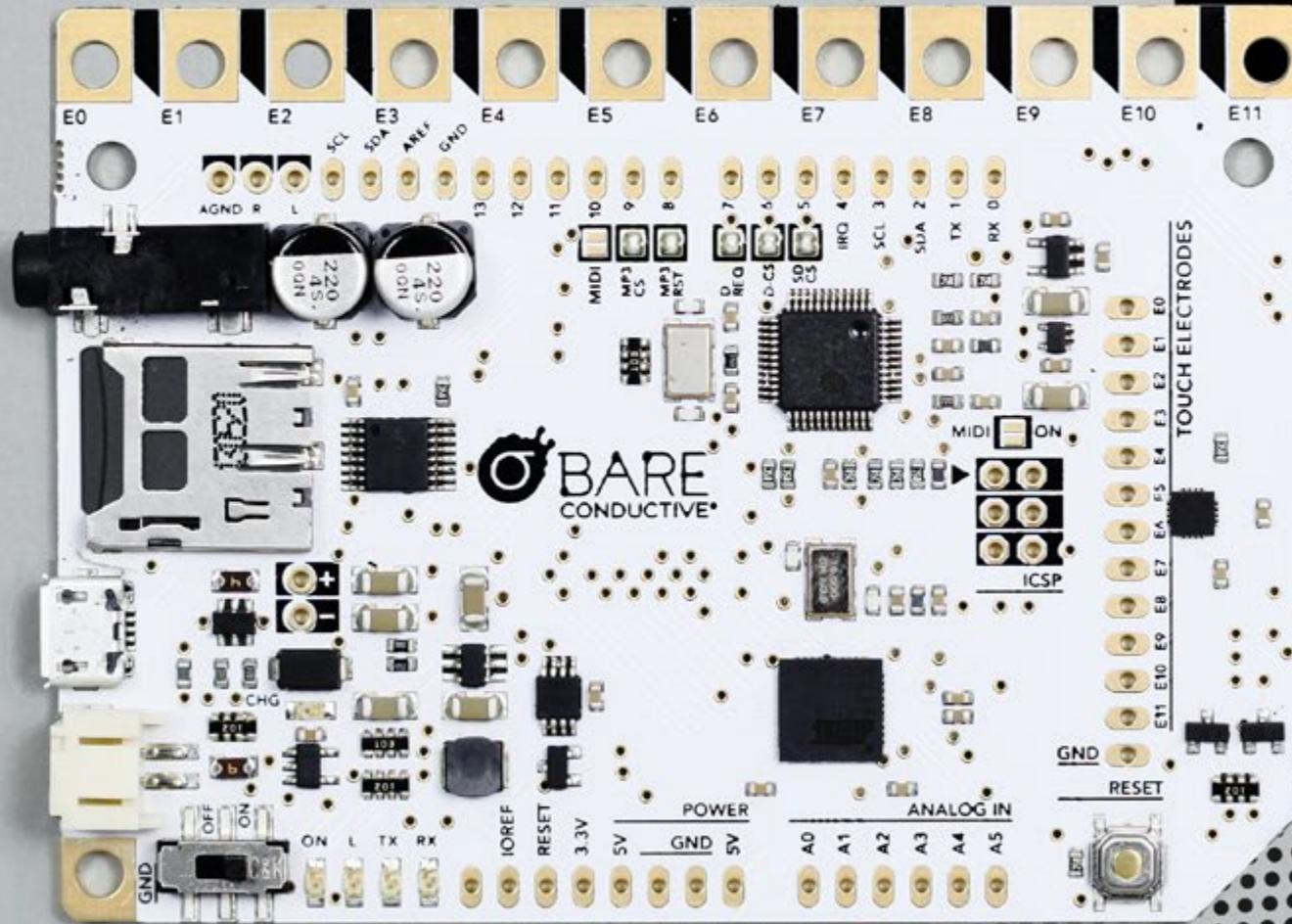




TECHNIQUES & INSPIRATION



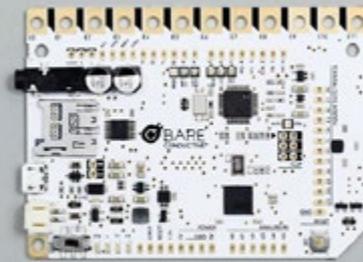
in1

in2

in2

HELLO

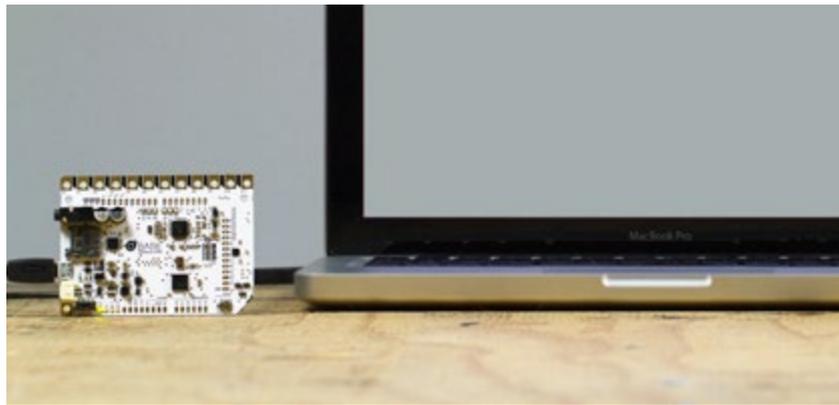
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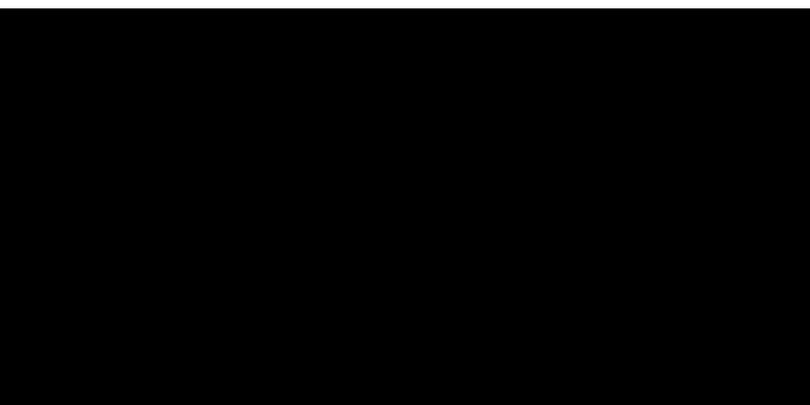
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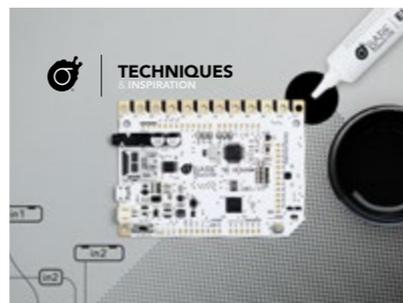


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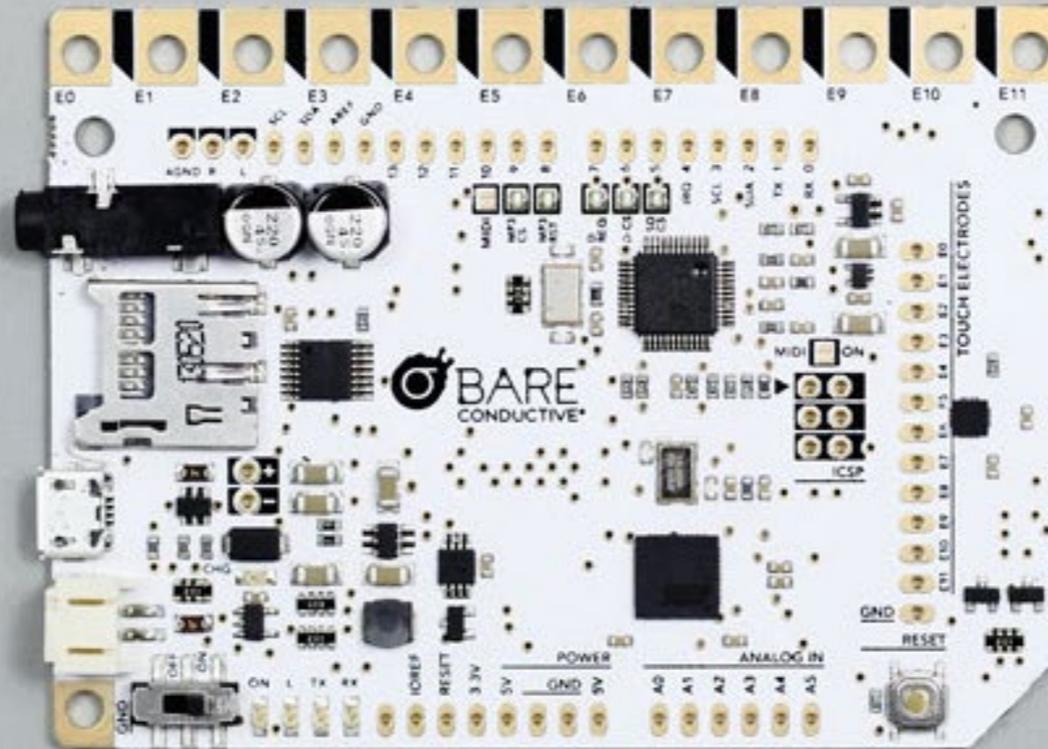


How to use this document

This document provides an overview of the wide range of techniques and tools that are compatible with **Electric Paint** and the **Touch Board**. The purpose of this document is not to provide step-by-step guidance, but rather to present the breadth of opportunities and outputs that are possible when using these technologies.

Whether your focus is on visual design, physical making, programming, or digital and analog interactions, this document will provide ideas, examples, and inspiration for you to get started. Mix and match the tools, outputs and techniques to create new project briefs or variations on existing ones.

If you're running a workshop, you can present this document as a whole during your introduction, or select a few relevant sections that fit with your chosen theme.



Key Features

- ▶ Touch and distance sensing
- ▶ Arduino-compatible
- ▶ No programming required
- ▶ Works with Electric Paint
- ▶ MP3 player / MIDI device
- ▶ Use as an Arduino
- ▶ MicroSD Card socket
- ▶ Standard 3.5mm audio jack
- ▶ LiPo battery charger
- ▶ HID capable

TOUCH BOARD®

The Touch Board is an Arduino-compatible microcontroller, with the power to turn almost anything into a sensor. It has 12 electrodes running along the top edge of the board which can be used as touch or proximity sensors. Straight out of the box, the Touch Board comes preprogrammed as an MP3 player. However changing the code on the board allows you to use it for outputs other than MP3. Trigger any output you like, sound, movement or light. Use it as a MIDI synthesiser, or send MIDI messages to another device like an iPad or a laptop running Ableton Live.

**Key Features**

- ▶ Paint circuits and cold solder components
- ▶ Non toxic
- ▶ Can be applied to a range of materials
- ▶ Suitable for screen printing

Technical Specifications

- ▶ Electrically conductive
- ▶ Water-soluble
- ▶ Surface resistivity:
55 Ω /sq @ 50 microns
- ▶ Drying time: 10–15 min
- ▶ Meets EINECS / ELINCS and TSCA safety standards

ELECTRIC PAINT®

Bare Conductive's Electric Paint is an electrically conductive, nontoxic, water-based paint. It can be used to cold solder and repair small breaks in circuits, or to paint wires and sensors. It works on paper, plastic, textiles, wood, plaster, glass, and most other materials. Electric Paint is a unique material for prototyping with electronics allowing you to integrate electrical properties into traditionally inert mediums such as painting, screen printing and other visual arts techniques.

OUTPUTS



TOUCH MP3

The Touch MP3 code comes preprogrammed on the Touch Board when it ships. It allows you to touch any of the electrodes, or sensors connected to them, and play one of the MP3 files stored on the board's microSD card. You can create lots of fun projects with this code without having to program the Touch Board. Make interactive posters, intruder alarms, paper craft doorbells and more.



CARDBOARD BOOMBOX

The Boombox is a great demonstration of a standalone project using the Touch Board. It takes advantage of Electric Paint and a LiPo battery to make a working cardboard boombox. This project can be made combining an audio kit from an electronics supplier, screen printed or painted graphics for the interface, and the Touch Board for the sensors and audio storage.

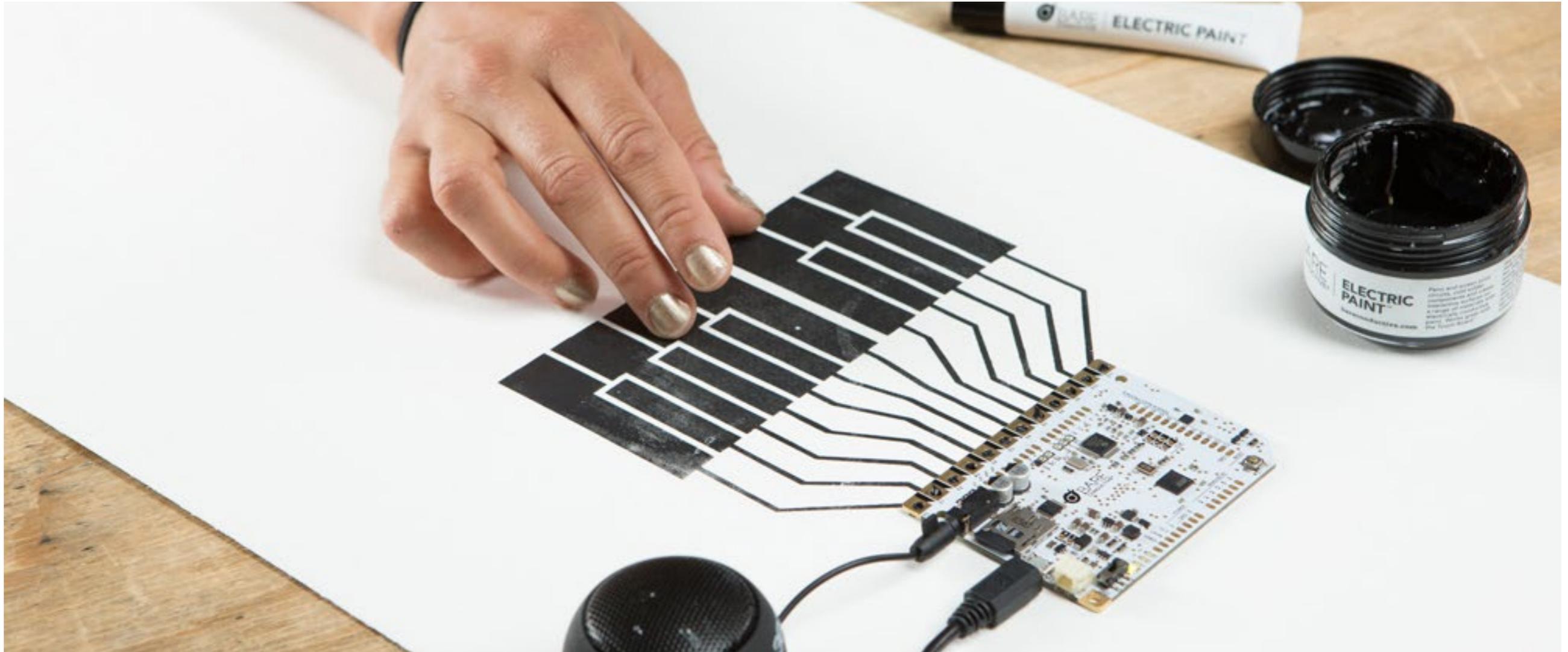


RESPONSIVE NARRATIVES

Creative agency BBDO Guerrero brought a classic Filipino novel to life using the Touch Board with its simple Touch MP3 code. The exhibit features illustrations of characters from the book, that narrate parts of the text when touched.

Images courtesy of BBDO





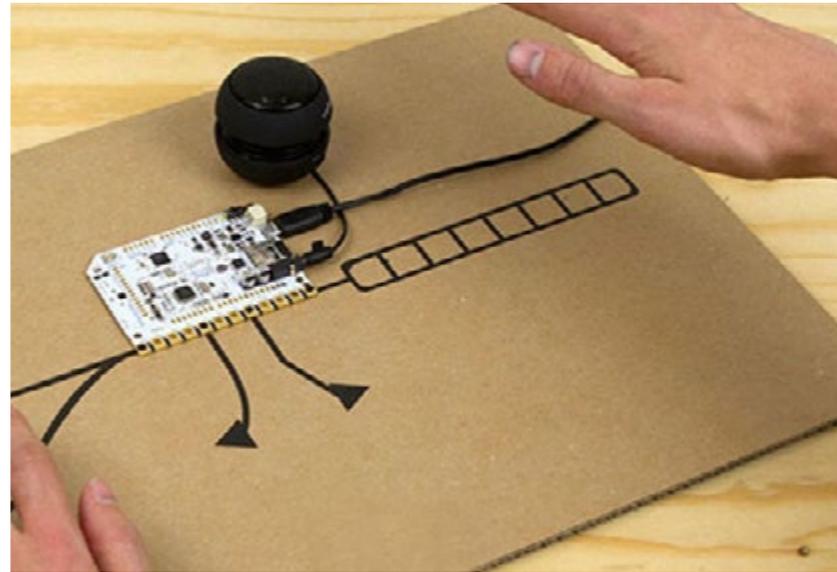
ON BOARD MIDI

With a couple of easy modifications to the Touch Board, we can use it to play back audio from MIDI data. The board uses its inbuilt synthesiser via the stereo headphone socket. This offers a much wider choice of sounds compared to the MP3 mode, selecting the sounds from a bank of predefined instruments. It also means several notes can be played back simultaneously, just like playing a chord. We can turn the Touch Board into a piano, drum kit, clarinet or even a theremin.



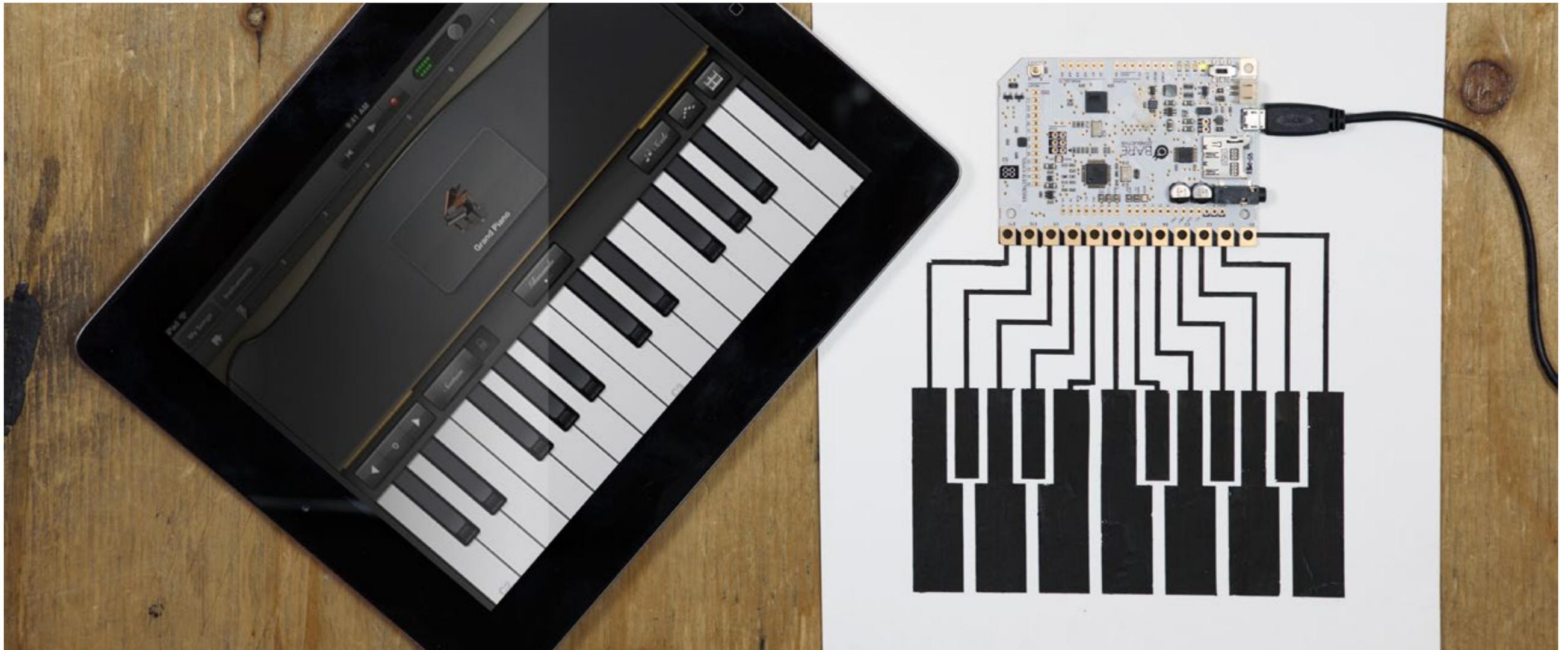
PROXIMITY + MIDI

You can trigger the Touch Board's MIDI from a distance. This is done by reducing the sensor threshold in code. Triggering sounds with a wave of a hand is no problem, leading the way for more intuitively triggered and controlled musical instruments.



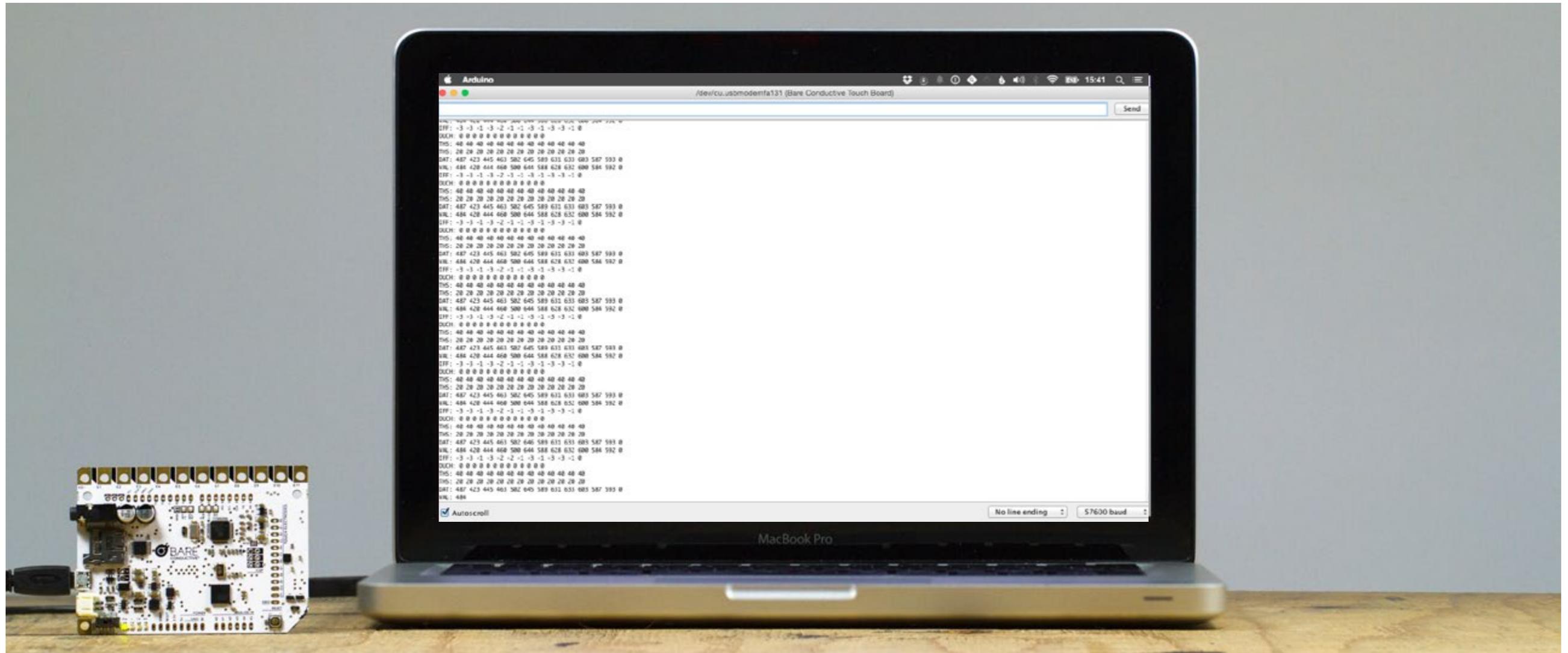
MIDI THEREMIN

The theremin is an early electronic musical instrument that is controlled or played without physical touch. It is controlled via two metal antennae that sense the relative position of the player's hands. One of the antennae is for controlling the frequency and the other for volume. The result is a wonderfully eerie sound coming out of an instrument you don't even need to touch. Although the metal pieces are called antennas, they are not broadcasting radio waves, but are working as plates of a capacitor.



MIDI CONTROLLER

As well as playing back MIDI data as synthesised audio via the stereo headphone socket, we can send this data out via the USB connection to a computer without any modifications to the Touch Board. This allows an external program like Ableton Live or Garage Band to do the synthesis for us, enabling more sophisticated outputs. It also allows us to pass proximity data as MIDI 'control change' messages - a bit like turning a control knob or moving a fader up and down. This allows continuous variation of parameters as well as digital 'note on' and 'note off' events.



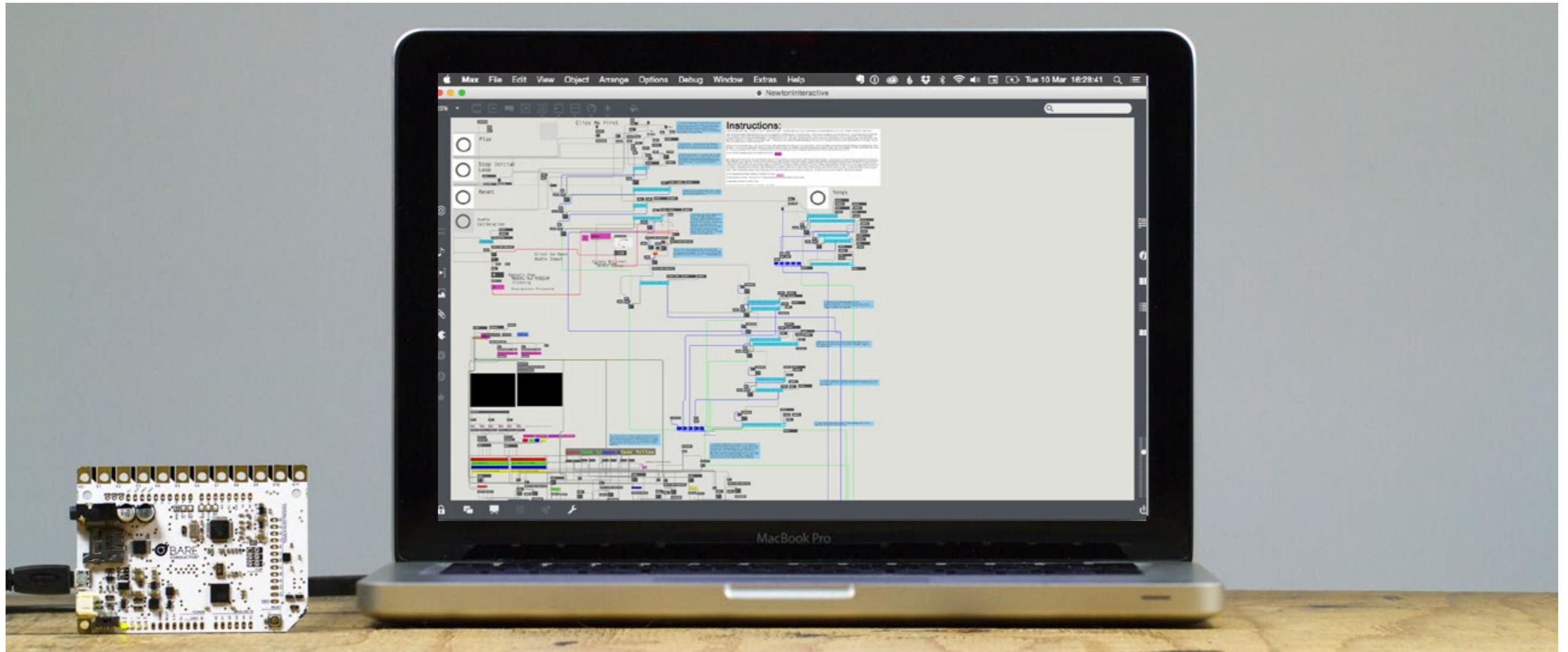
DATASTREAM

Our Datastream code takes all of the raw data from each capacitive sensing electrode and streams it via the USB port as human readable serial data. This allows you to connect a computer to the board and access all the data directly to process as you wish — although you will need to write your own program to do this. We have examples written in Processing (our Grapher) and Max/MSP that you can work from.



DISTANCE SENSING

Although it's called the Touch Board, what the board is actually doing is sensing proximity via capacitive sensing. If we set our thresholds to be relatively high, this rejects proximity events and only responds to touches. However, if we want to sense through a non-conductive material such as plastic or glass, we can lower these thresholds to improve sensitivity — effectively turning the Touch Board into a 'Proximity Board'.



Max/MSP

The Touch Board works great with Max/MSP, which is a visual programming language that helps you build complex, interactive programs without any prior experience writing code. Our example Max/MSP patch shows you how to interface with a Touch Board running our Datastream code to trigger visual responses.



DATAFLAGS

Dataflags, created by Fabio Lattanzi Antinori were made using the Touch Board, screen printed Electric Paint and Max/MSP resulting in polyphonic, real time, data driven soundscapes.

Image courtesy of Fabio Lattanzi Antinori



POLYPHONIC PLAYGROUD

Studio PSK created the installation Polyphonic Playground with the Touch Board and Max/MSP. The program was used as an intermediary between the Touch Board and Ableton Live, mapping the precision of the Touch Board's sensors to the power of Ableton Live's audio processing.

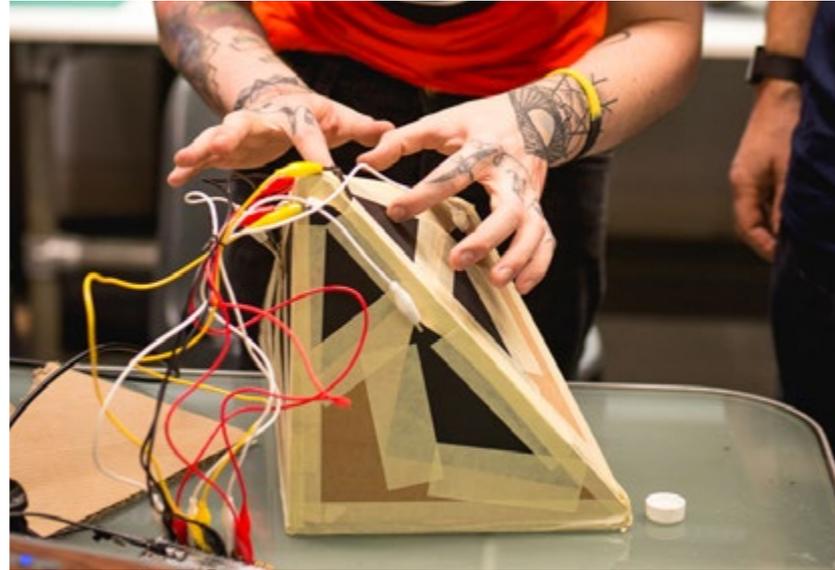
Images courtesy of Studio PSK





ABLETON LIVE

Ableton Live is a MIDI compatible digital audio workstation. With the Touch Board running our USB MIDI Interface code, we can send MIDI messages from the Touch Board which Ableton can react to and use to trigger, synthesise and modify audio. These include 'Note On' and 'Note Off' triggers along with 'Control Change' (CC) messages, which can be mapped to knobs or sliders.



3D MIDI CONTROLLER

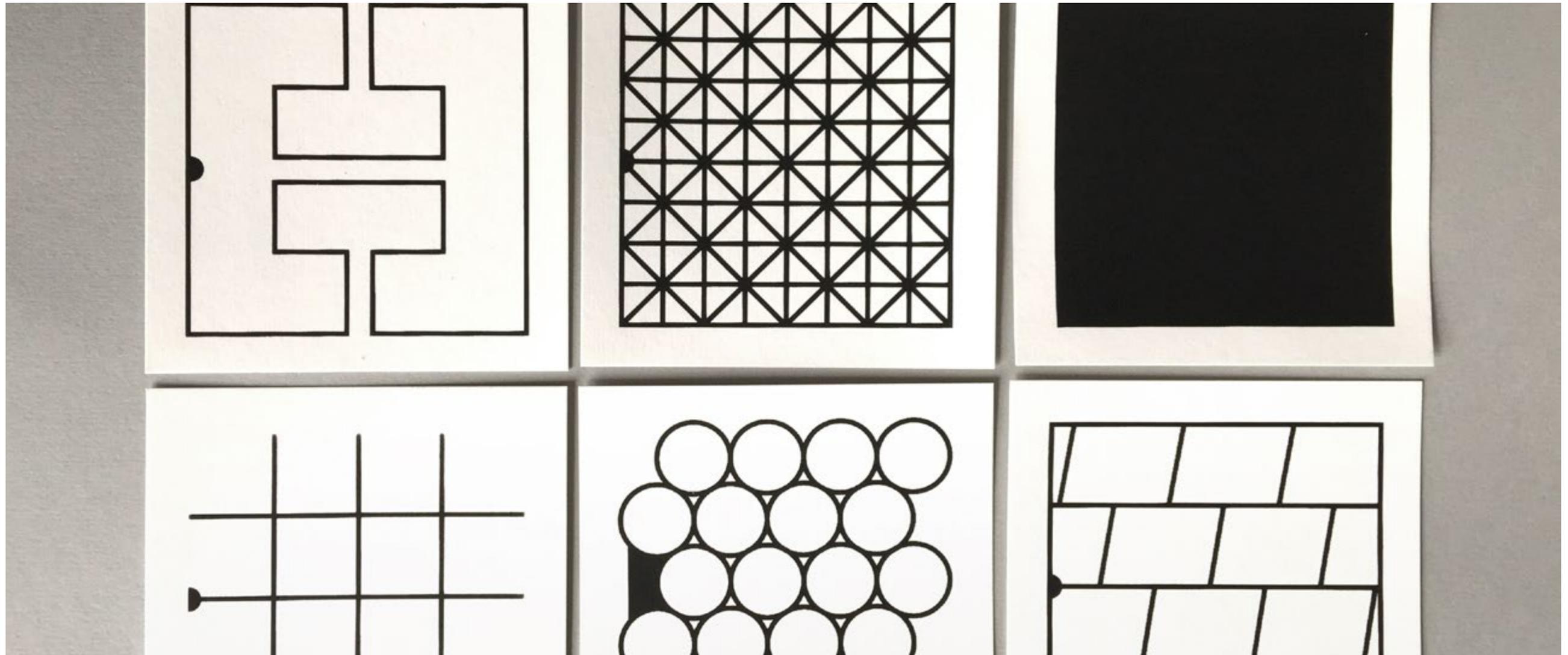
Adam John Williams created a 3D MIDI controller with cardboard, painted sensors and the Touch Board connected to Ableton Live. The Touch Board was programmed as a MIDI controller and each sensor was mapped to control a different action in the program, resulting in an intuitive, flexible digital instrument built with everyday materials.



GRAPHER

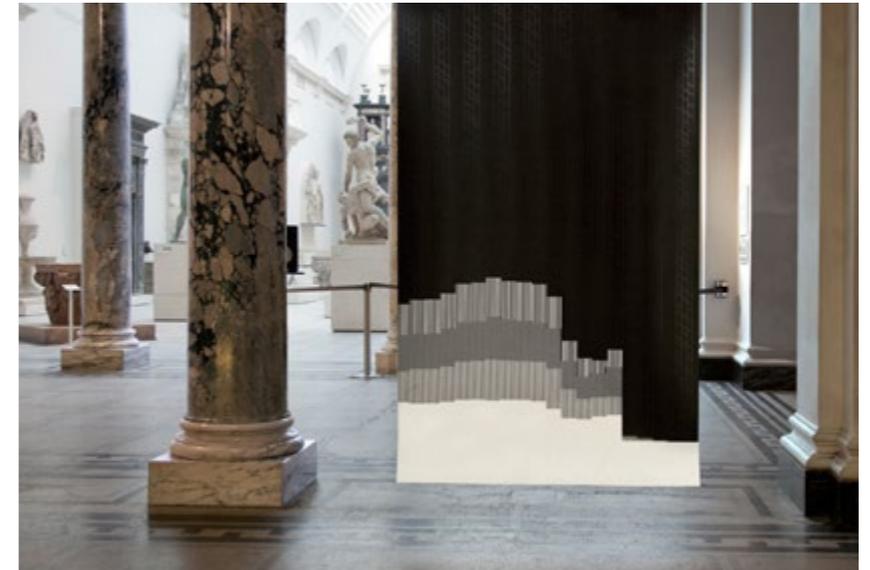
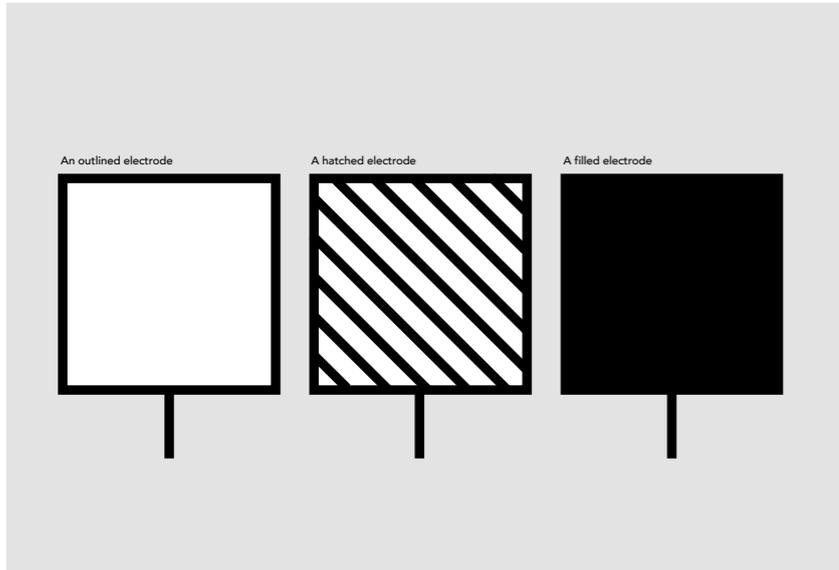
Our Grapher is a Processing sketch written to visualise and plot data passed to it from a Touch Board running our Datastream code. It visualises the raw proximity data captured from each electrode and displays touch and release events. It is useful for debugging installations and observing the range of signal variation you get with proximity. The source code could be adapted for the basis of your own program for interfacing with the Touch Board.

TECHNIQUES



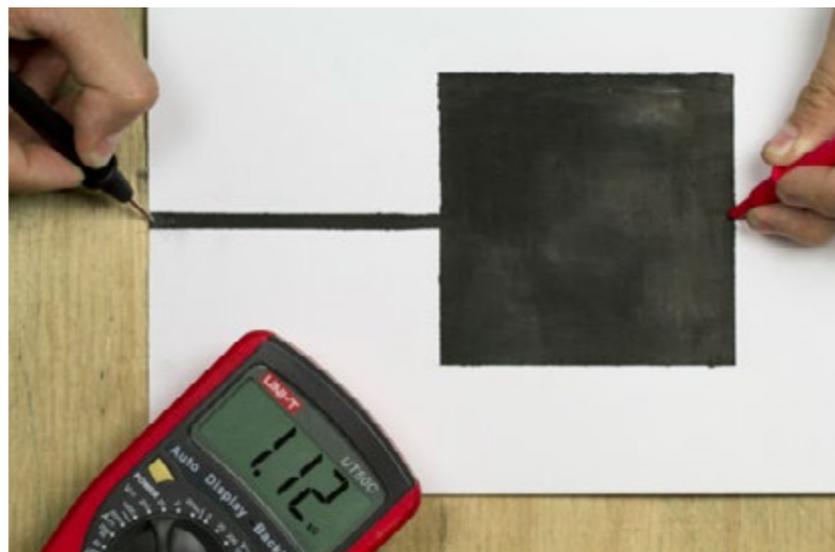
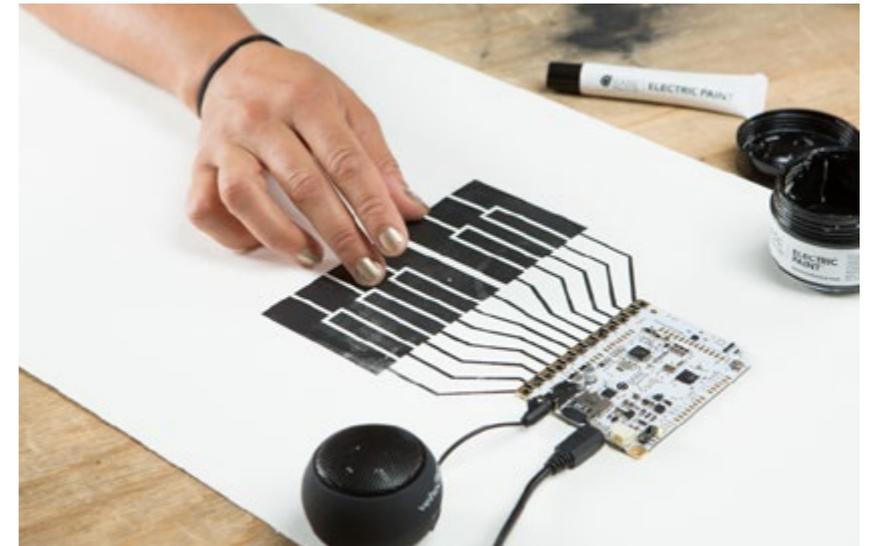
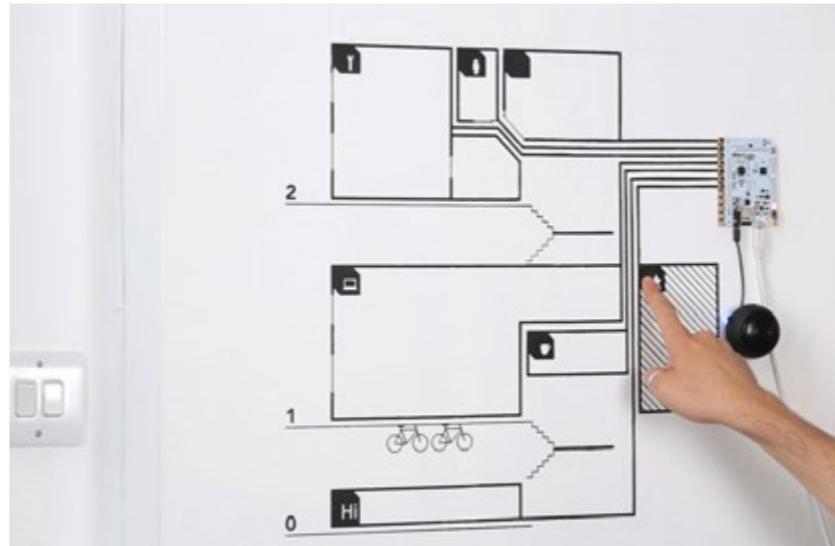
SENSOR DESIGN

When designing painted sensors to attach to the Touch Board there is a basic rule of thumb that can help. The size of the trigger (i.e. your hand or finger) should be relatively large in comparison to the sensor. This rule can be broken when doing touch sensing, but is more important to note when designing large proximity sensors. By hatching the sensor, instead of filling in the whole shape, you keep the amount of conductive matter low in comparison to the trigger, at the same time keeping the sensing area large. That said, there is no better way than experiencing this correlation by painting several different sensors and testing their behaviour.



SENSOR SIZES + DESIGN

All three sensor examples shown here will work with the Touch Board. They can be painted right to the board, clipped with alligator clips or attached with copper tape. If working at a large scale, hatching the sensor will allow you to cover a larger area using the same amount of paint as the filled in sensor. It's a good idea to bridge the hatched lines to allow for the sensor to work even if the line breaks in some parts. Creating different graphics using the same amount of Electric Paint does not change the performance of the sensor — so it's open for visual experimentation.



- 1. Screen printed fabric makes this flexible MIDI controller by EJTech
- 2. Interactive floor plan at the Bare Conductive studio
- 3. Measuring sensor resistance
- 4. Dataflags by Fabio Lattanzi Antinori
- 5. Screen printed MIDI piano with Touch Board
- 6. Painted light switch

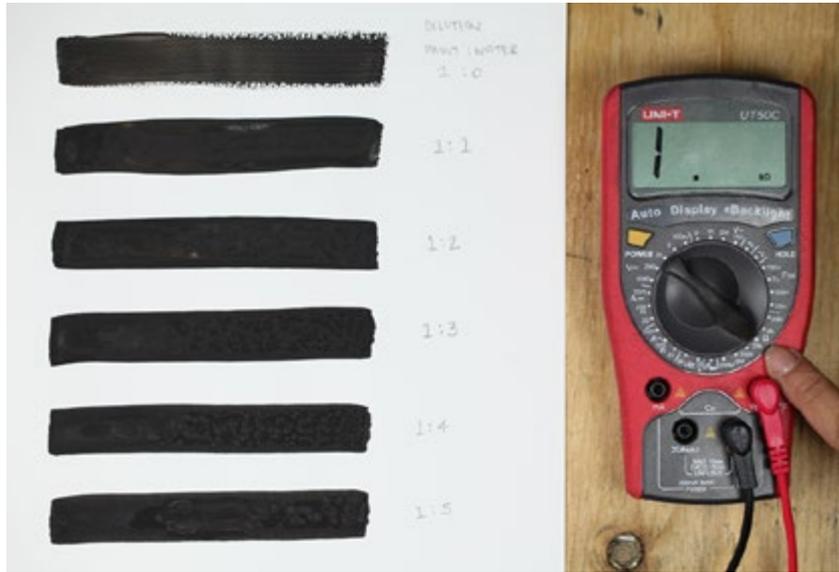


DILUTING

Electric Paint can be diluted with water to work through a spray nozzle, or to create a variation in tone. Because the paint is composed of conductive particles suspended in a water-based solution, doing this will decrease the conductivity of the material as the ratio of conductive particles to water decreases.

When applying the diluted paint, it's important to build layers of the dilution if you want to achieve the same measure of conductivity as the original material. You can always test with a multimeter to see if it is adequate for your application.

DILUTING



TECHNICAL TESTS

The resistance of Electric Paint increases when diluted with water. You can see from the images on the left how there is a linear increase in resistance as more water is added to the paint. This means that the more water we add, the less conductive the paint becomes.

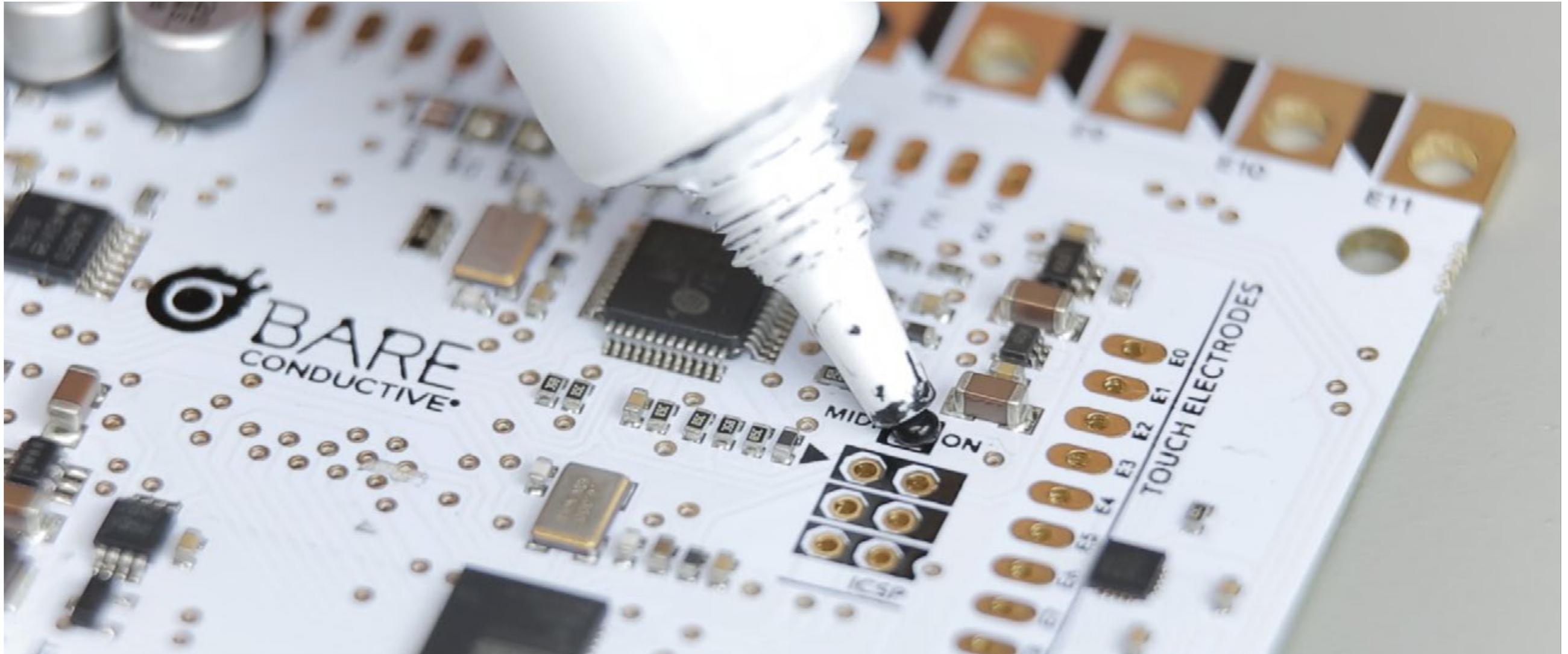


PAINTING TESTS

Diluted Electric Paint can be used in a more free-form and artistic way. These sensors were created with a watercolour technique called 'wet into wet wash', on a heavy rag watercolour paper, which holds a lot of water and pigment. In this technique the paper is brushed with a wash of clean water first, followed by washes of diluted Electric Paint to create soft gradients. The paper should be dried after each wash sequence to allow the Electric Paint to build up the conductivity.



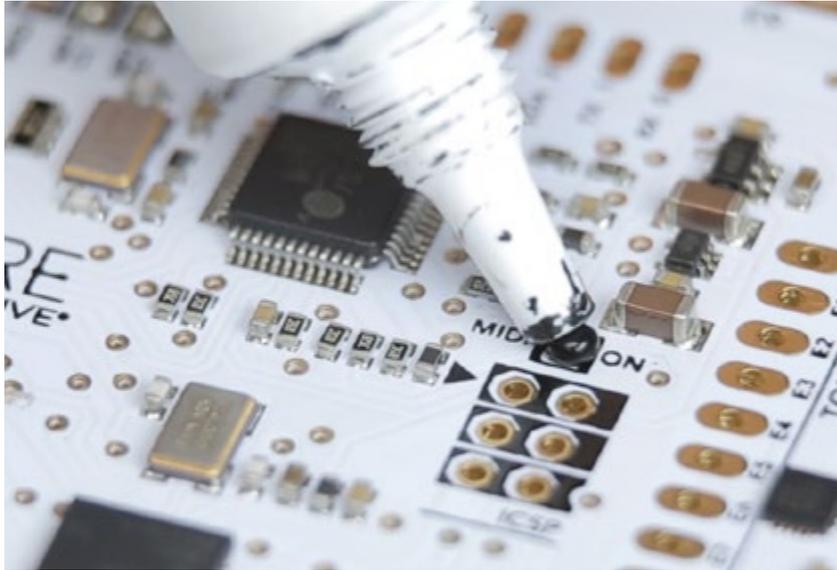
This watercolour technique creates a surprising style for a sensor. Try combining it with the Touch Board and Proximity code, which can be found on our GitHub.



COLD SOLDERING

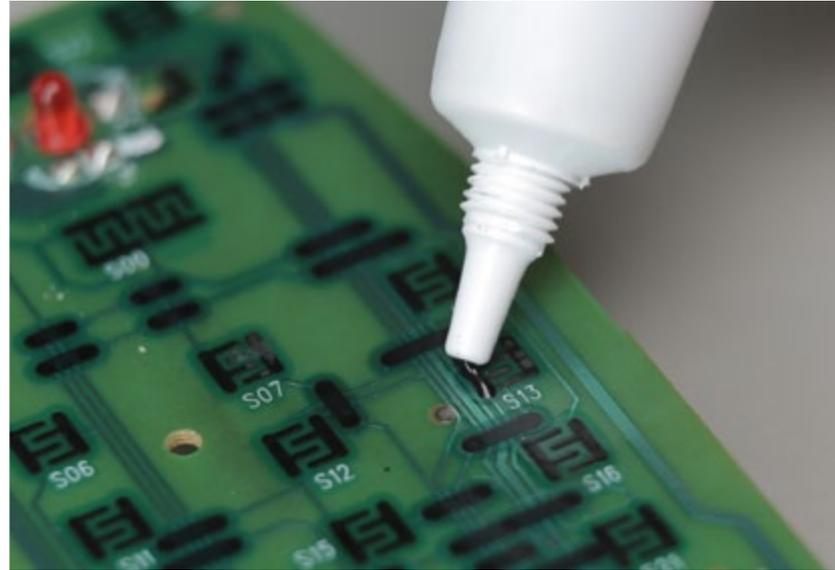
The Electric Paint 10ml Tube is a great precision applicator. The fine tip and flexible packaging allows for a controlled flow of paint, which lends itself well for cold soldering.

Cold soldering is a good technique to keep things in place for prototyping or PCB repair. The image above shows Electric Paint being used to bridge the MIDI contacts on the Touch Board to activate the on board MIDI mode.



COLD SOLDER FOR ON BOARD MIDI

Electric Paint is a great material to use for the MIDI cold solder joint on the Touch Board. The paint is easy to apply, but also to remove, so you can easily take it off if you want to revert your board's functionality to something other than MIDI mode.



FIX A REMOTE

Some of the circuit boards inside remote controls are printed with a carbon material not dissimilar to Electric Paint paint. When these printed tracks wear away, the bridge the button creates in the circuit is broken and the buttons can stop working. The same can happen with the rubber buttons which have a small carbon pill on their reverse, which bridges the traces on the circuit board. Both of these are great examples where Electric Paint can be used to repair.



TOUCH BOARD TO PAPER

One of the best features of the Touch Board is its electrode edge plating. This allows sensors to be painted directly to the board using Electric Paint.

Because of the board's surface mount design it can also sit flush on any surface, allowing for seamless integration onto paper or cardboard projects.



COMPONENTS TO PAPER

Electric Paint works as a conductive adhesive. As such it doesn't require a metal connection or heat in order to attach or solder. This means you can cold solder components onto nontraditional materials such as paper, cardboard or plastic without damaging them. Simply squeeze a droplet of paint onto each component leg, making sure the paint makes good contact with the rest of the circuit.



PAINT A CIRCUIT

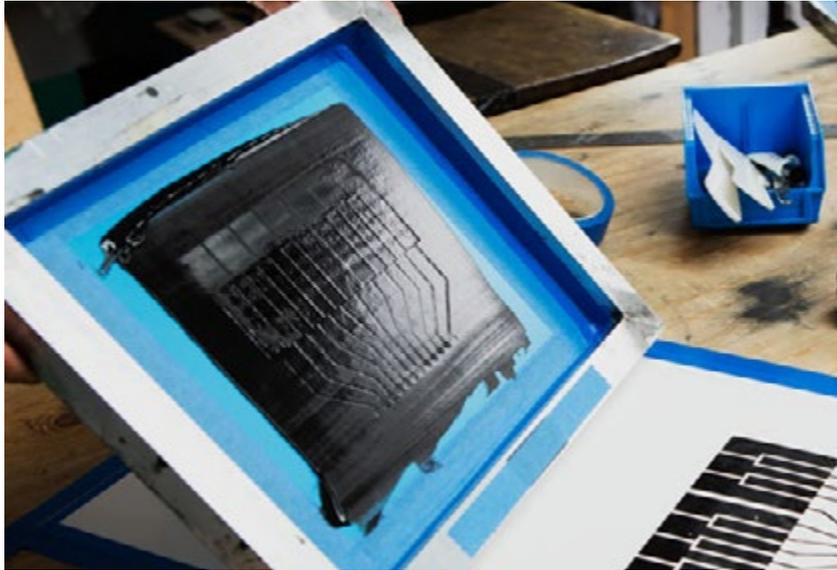
Electric Paint can be used to paint small and simple circuits. This feature is useful when using the paint on non-traditional materials, or when prototyping or testing circuits.

Painting circuits is a great activity for introducing the basic principles of electricity to beginners or young students.



SCREEN PRINTING

Electric Paint is a unique material that can be applied in many different ways, from a paintbrush to common printing processes like screen printing. To achieve consistent electrical performance it is best to apply Electric Paint in an even layer. If you're interested in screen printing Electric Paint, it is best to use a textile type screen in order to achieve a generous layer thickness. We tend to use a 43T screen. Electric Paint is not inkjet printer compatible.



TIPS

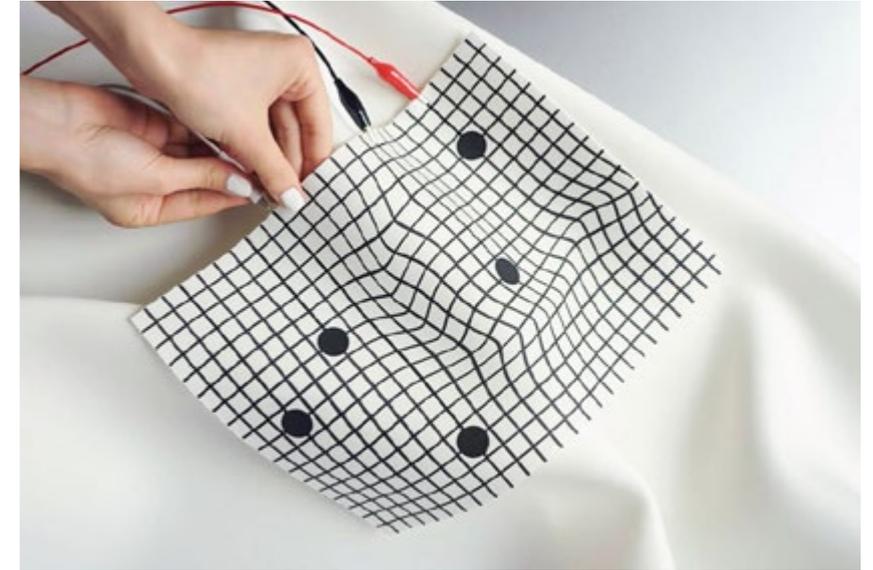
For quick prototypes without the need of exposing a screen, it is possible to use a vinyl stencil applied right to the mesh. For small prints no screen printing specific table is needed.

Electric Paint can be washed off the screen with water, but it does tend to dry quickly so several cleans may be required for large runs.



INTERFACES

The Touch Board Boombox features a screen printed interface, which was designed to emulate the original button design, hosting the Touch Board in place of a tape deck. Through experimenting with different layouts we found that the Electric Paint should not run behind the Touch Board as it can create unwanted contacts which affects the MP3 Touch capabilities.

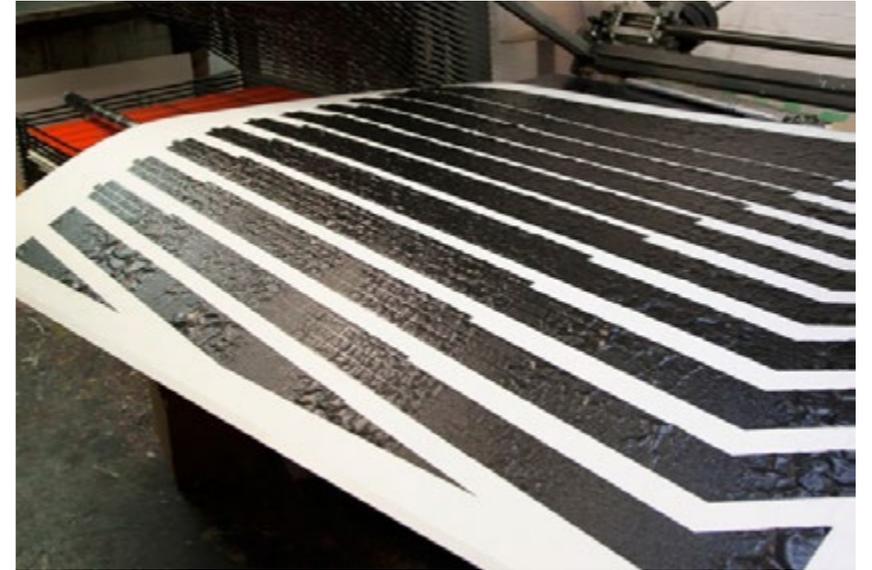


FLEXIBLE MIDI CONTROLLER

This flexible MIDI controller by EJTech was made by screen printing Electric Paint onto fabric. The team used an Arduino Mega ADK to communicate with Max/MSP and Ableton Live to play MIDI notes when touched, an action also achievable with the Touch Board.

Image courtesy of EJTech

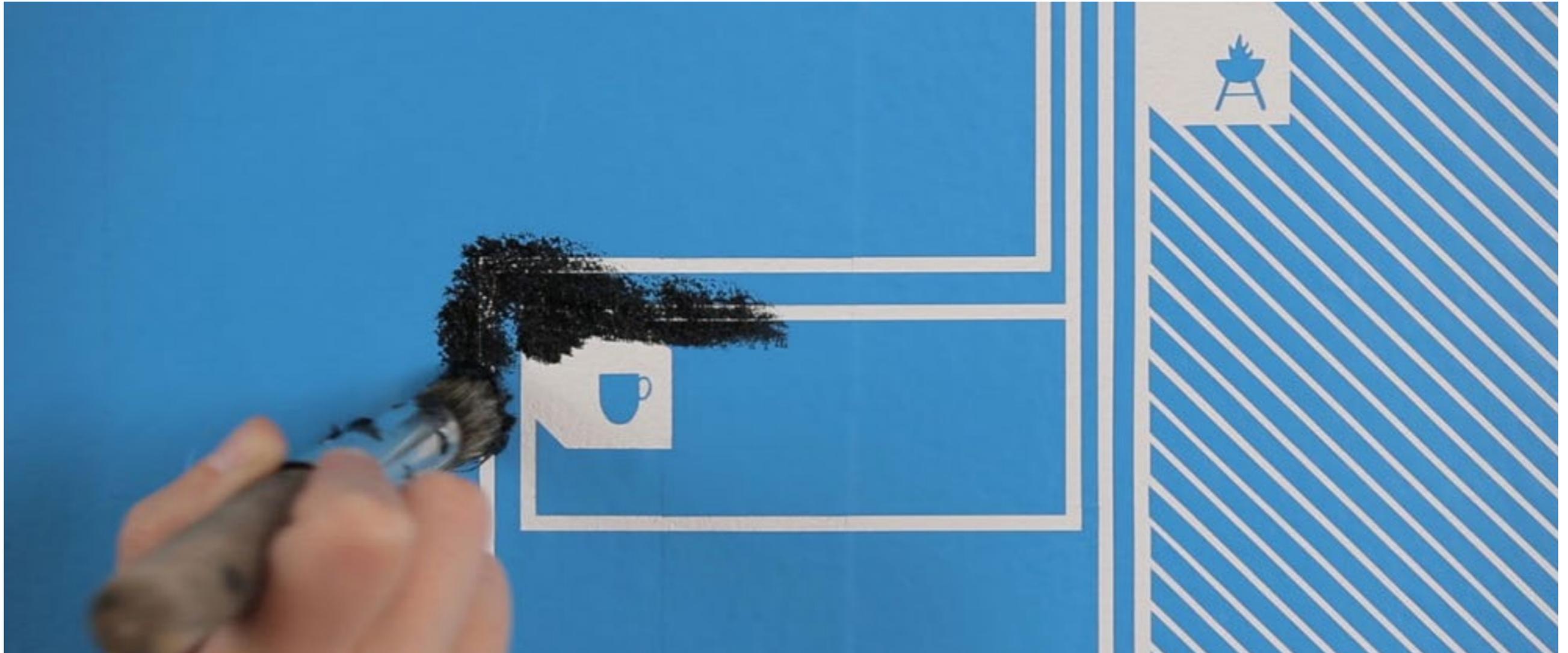
SCREEN PRINTING



INTERACTIVE PRINTS

Both Dataflags and Contours installations by Fabio Lattanzi Antinori are screen printed with large Electric Paint sensors, measuring 1.6m in length. A second layer of standard oil based screen print colour is overprinted to seal the Electric Paint and create a strong visual impact. These are great examples of sensors at scale.

Images courtesy of Fabio Lattanzi Antinori



STENCILLING

Electric Paint can be applied using a wide range of stencilling techniques. You can use paper, vinyl or everyday materials, such as laser cut paper, film or even masking tape. A good way of making a stencil is to use vinyl – this can give you crisper edges and more detail. In particular, vinyl is great for creating text because the whole sheet is adhesive so it can fill up the whole screen, and can be cut manually with a craft knife or robotic cutter.

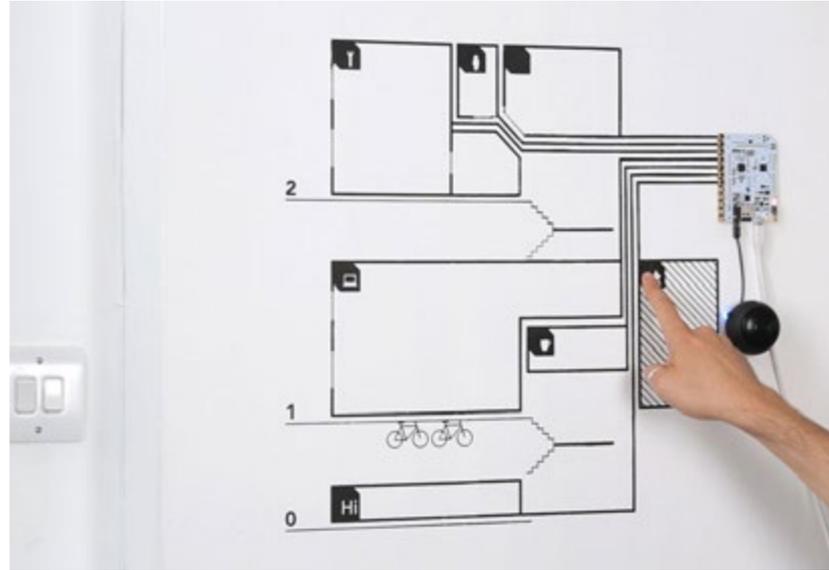


PAINT APPLICATION TIPS

When stencilling it is important to use the correct application technique to get a nice clean finish. Applying the paint with a flat-ended paintbrush is called stippling.

Dip the tip of your Stencil Brush in the Electric Paint 50ml Jar. Make sure to 'offload' the excess paint onto newspaper so that your stencil doesn't stick. The bristles on your brush should not be too saturated with paint when you blot it on the stencil. A 'dry' brush will prevent the paint bleeding under the lines.

To apply, repeatedly tap the brush onto the stencil to build up the layer of paint gradually. Make sure you get a thick coat of paint. Once you're happy with the coverage, leave it for 15 minutes or until completely dry to the touch.



EXAMPLE PROJECTS

Here is an example of a graphic created with a vinyl stencil. It is an interactive floor plan of our studio on the wall. We used our Stencil Brush to apply Electric Paint to the wall. The Touch Board is used to add audio descriptions of each room to help guide visitors around the space.

This house graphic comes as part of Touch Board Starter Kit, which includes a laser cut Mylar stencil as well as paper shapes to create a interactive storytelling wall graphics.





SEALING

Electric Paint is water soluble and can be washed off hands easily with soap and water. This also means that it is not totally permanent when applied to a surface, especially if it is being repeatedly touched or flexed. Interactive artist Thomas Evans shared some of his secrets to achieve smudge proof and robust graphics with Electric Paint and sealant.

Images and content courtesy of Thomas Evans



MOD PODGE

Mod Podge is a material mainly used for scrap booking, and is one of the best solutions for sealing Electric Paint. It can be picked up for under \$10 at craft shops or online, and acts as a bonding agent like a glue, and can be used to create a very thick seal over painted areas. Apply by using a soft bristle brush in short single strokes after allowing the Electric Paint to dry thoroughly. Using a hard brush may cause the paint to reactivate and smear as you make the brush strokes.



CLEAR COAT

Clear coat spray is a great way to seal large areas of Electric Paint, and can be found in most hardware store for a very reasonable price. It's quick to dry and easy to apply in well ventilated areas, plus you can layer it to create thicker seals. You don't need a brush either, so it won't disturb the paint underneath.



TESTING

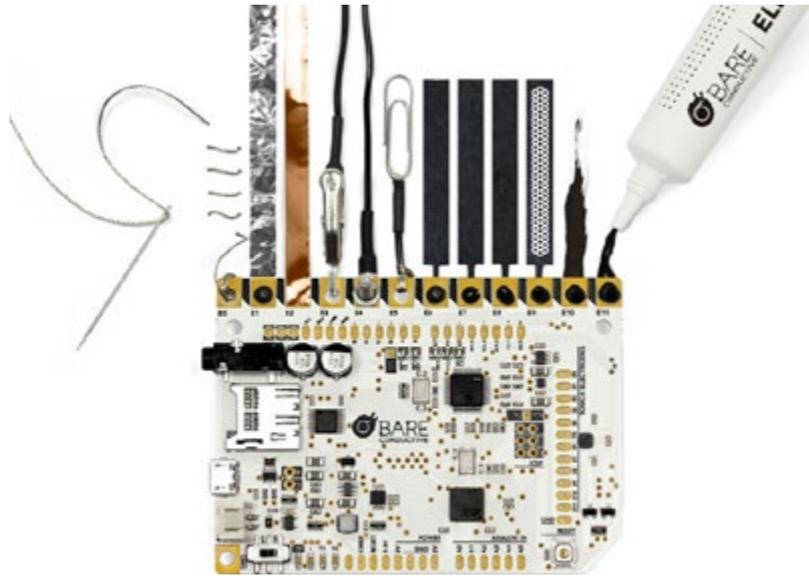
This image shows the results of an experiment sealing Electric Paint with the two materials. The line on the left is protected with two layers of the clear coat spray and the line on the right is protected with Mod Podge. The middle line is an unprotected. You are able to see the different effects of stroking a wet brush over each line. Only the unprotected line is subject to smearing when contacted by water. Both protected lines are undisturbed by the wet brush.

BEST PRACTICE



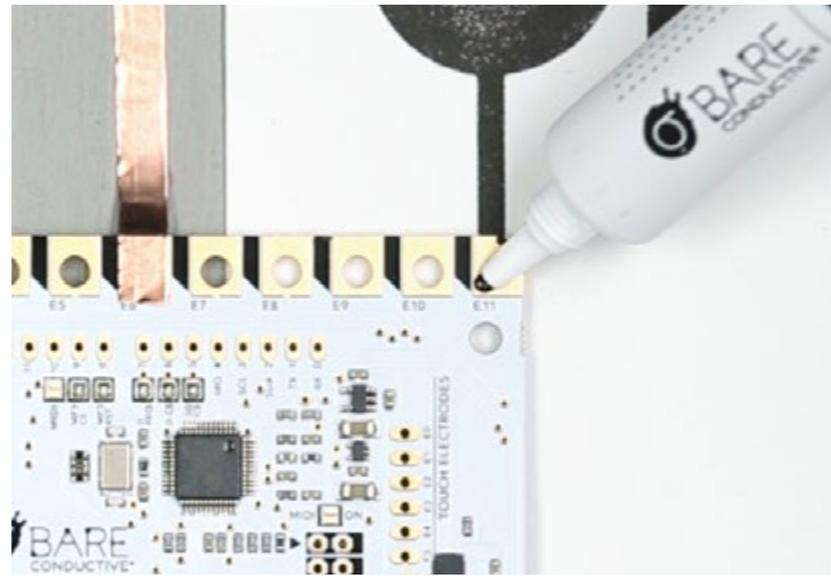
CONNECTING

Connecting objects to the Touch Board to create sensors is easy. You can use standard fittings like alligator clips and small bolts, or loop conductive thread through the electrode holes. One of the best features of the Touch Board is the unique edge plating of the electrodes, which allows you to paint sensors right from the board itself. The board's surface mount design means it can sit flush with any surface making integration into your projects easy.



TIPS

You can connect to the Touch Board in a wide variety of ways, some of which are shown on this image. The large holes in the electrodes allow for many materials to be 'threaded' through, this includes anything from wire, small bolts or conductive thread. Conductive adhesives can be applied directly to the electrodes, while Electric Paint is a great way to secure or cold solder the Touch Board to the surface you're working on whether it is paper, wood or a wall.



ELECTRODE EDGE PLATING

The fact that the electrodes are edge plated means a connection can be made from any point around each one. The Touch Board can be connected to a surface or sensor directly with Electric Paint from either side of the board. Make sure that you don't bridge two electrodes that are next to each other with the paint, otherwise it might read two touches at the same time. If you are using the Touch MP3 code this will confuse the program and no sounds will play.



CONNECT CONDUCTIVE OBJECTS

Everyday objects make great sensors. Look around and explore what materials you want to bring to life – anything conductive can be connected to the electrodes on your Touch Board. Create quirky and unexpected sensors using wires and alligator clips to connect to your Touch Board.

Check out the Visual Guide to Conductive Sensors PDF for more inspiration.

INSPIRATION



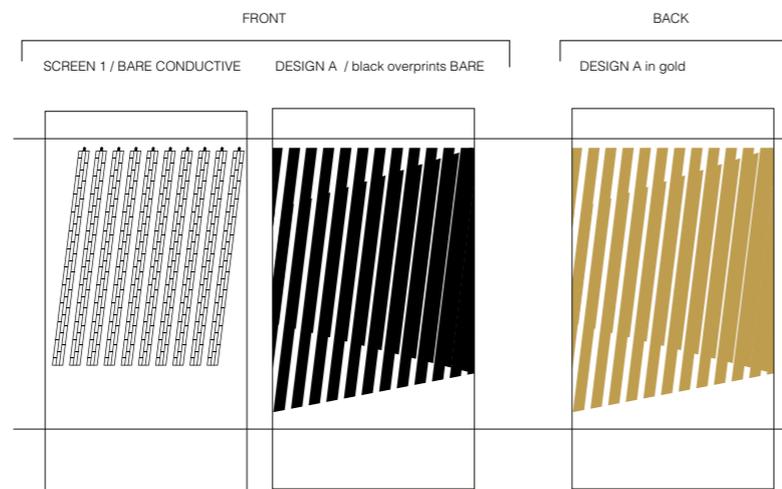
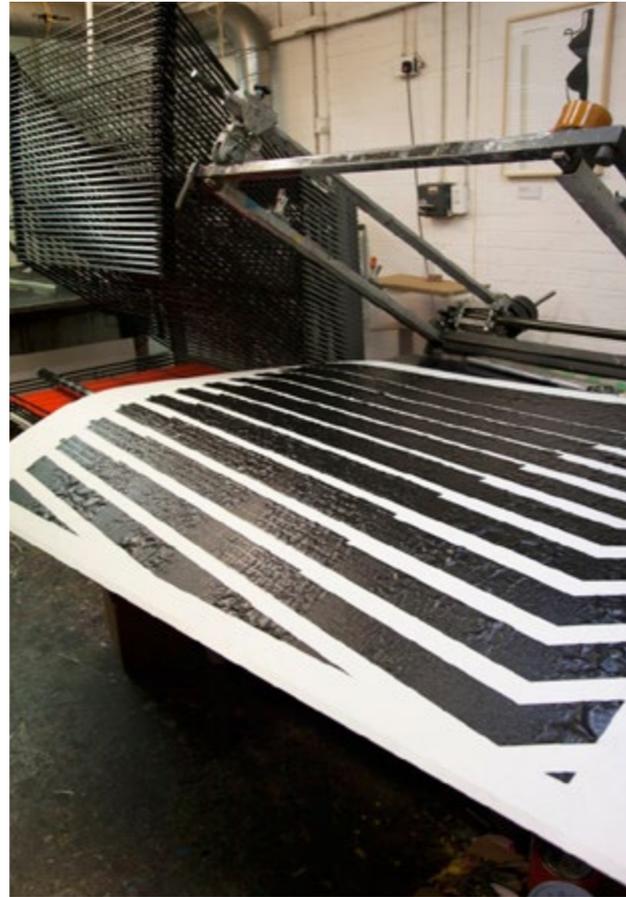
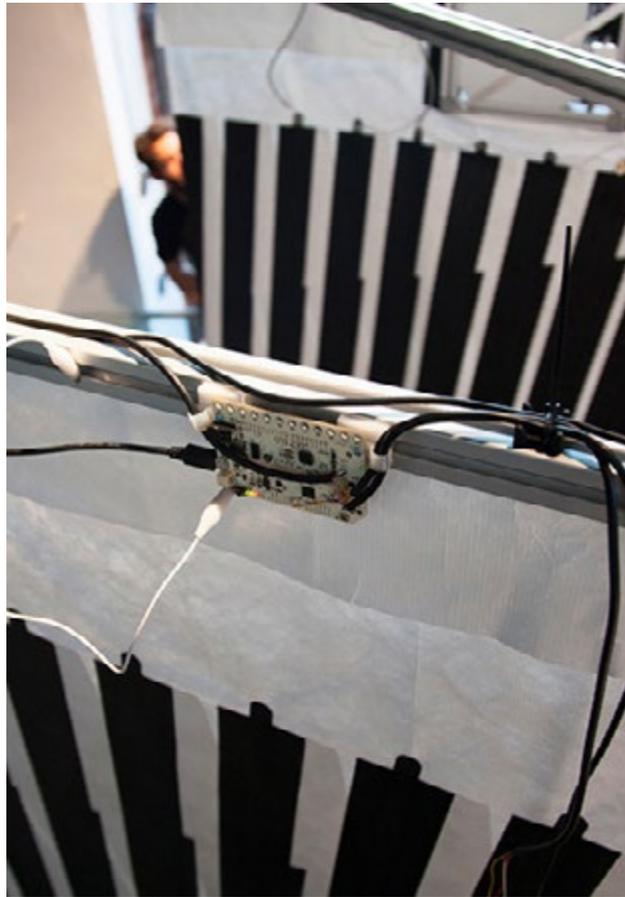
Contours

Responsive sound installation

Contours by artist Fabio Lattanzi Antinori and Alicja Pytlewska was installed in the MAK Museum, Vienna, in 2013. It was created using two metre-long pieces of Tyvek fabric, which was screen printed with Electric Paint and controlled by the Touch Board. The printed sensors reacted to the presence of a person and triggered an ambient soundscape composed in real time.

The Tyvek was printed in three stages, an initial layer of Electric Paint to create the sensors, a layer of nonconductive back ink to

conceal the sensors, and finally a gold print on the back. In technical terms, the only electrically active layer of material was the ten sensors printed on each sheet using Electric Paint.





Art and decibels

Interactive oil painted portraits

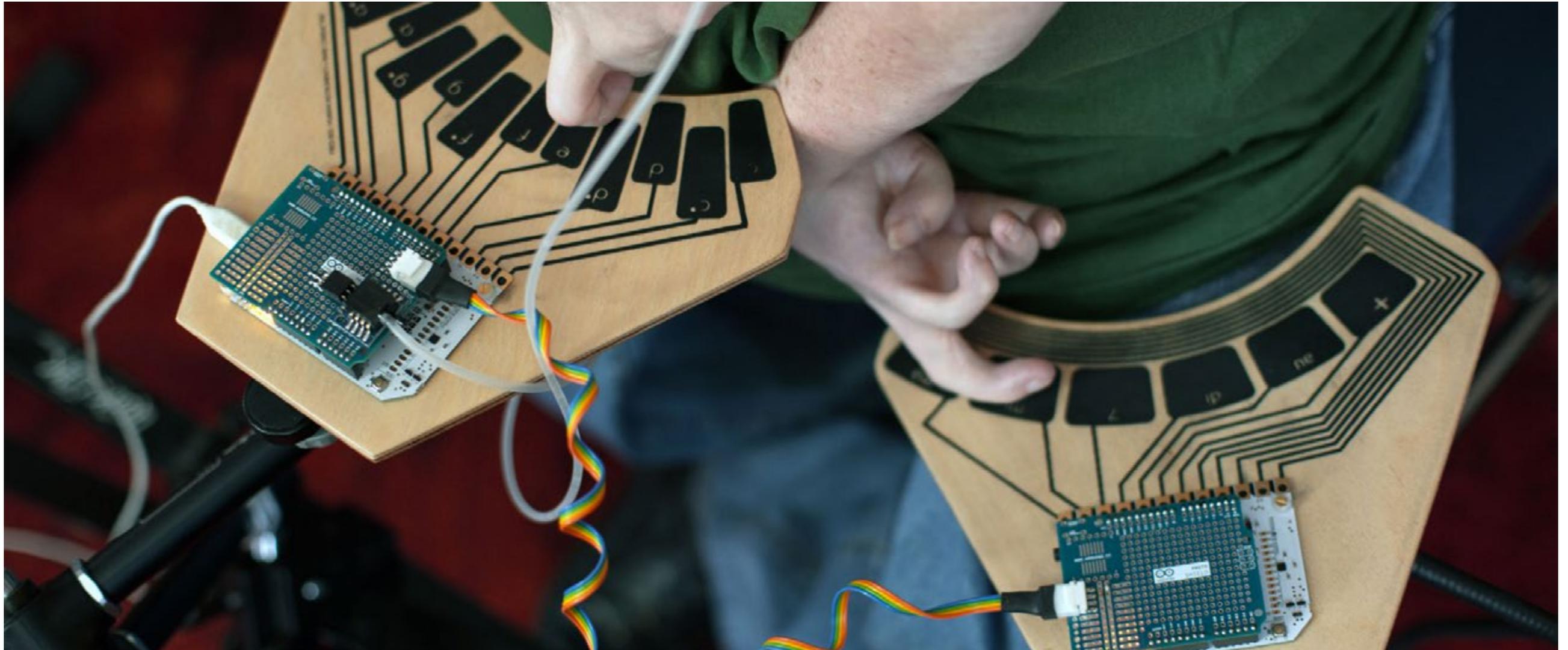
The work of Denver-based artist Thomas Evans doesn't just look impressive, but provides an touch activated experience. Each painting has hidden Electric Paint sensors connected to multiple Touch Boards and can be played like a MIDI controller in a gallery or during a live set.

All images courtesy of Thomas Evans



All images courtesy of Thomas Evans





Programming Expression

An expressive musical instrument

Vahakn Matossian from Human Instruments collaborated with Bare Conductive to create an expressive digital instrument with the Touch Board and Electric Paint. Unique in its form and output, this physically dynamic instrument uses code as a means to allow for complex musical expression.

The instrument can be used by musicians with ranging levels of mobility and strength to compose and create expressive sound.



All images courtesy of ?



DEFINITIONS

ARDUINO

Arduino is a platform that make easy to use software and hardware for creating interactive projects. The Touch Board works with Arduino software.

<https://www.arduino.cc/>

CAPACITIVE SENSING

Capacitive sensing is a proximity sensing technology. It detects nearby objects by sensing that the electric field generated by a sensor (in this case one of the 12 electrodes), has been disrupted. It can detect anything that is conductive or that has a significantly different **permittivity*** than that of air, like a human body or hand.

Capacitive sensing is the technology used in smart-phone screens to detect touch. It's also used in other situations where there's a need to detect human touch or proximity. It's also used when trying to detect something without touching it.

The Touch Board has 12 capacitive sensing electrodes, each of which can individually detect touch and proximity.

***Permittivity** [put-mi-tiv-i-tee] is the measure of the difficulty encountered when forming an electric field in a material. The ability of a substance to store electrical energy in an electric field.

CIRCUIT

An electrical circuit is a pathway that begins and ends in the same place, passing electricity through it. In a basic circuit there will be components that put this electricity to use as power passes to each component or device.

To be able to flow, electricity needs a conductive material as its pathway. Electric Paint is conductive, so it can provide this. How does it start moving in the first place? Electricity flows from a higher voltage (positive +) to a lower voltage (negative -). Batteries and some components will have a positive and negative connection (they exhibit **polarity***) so it's important to position them the right way round for electricity to flow through the circuit.

***Polarity** — Electricity flows from a higher voltage to a lower voltage. In a direct current (DC) circuit, the current flows in one direction only.

DISTANCE SENSING

Although it's called the Touch Board, what the electrodes are really doing is sensing proximity via capacitive sensing. When you set a sensor's thresholds to be relatively high, the Touch Board only responds to actual contact or touch, rejecting proximity events.

If you want the Touch Board to sense something from further away, or even through

an insulation such as glass or plastic, you can lower each sensor's threshold to increase sensitivity — turning the Touch Board into a 'Proximity Board'.

If you would like to change the sensitivity of one or more of the electrodes on your board, just follow the proximity tutorial on the **bareconductive.com** website.

GITHUB

GitHub is a platform that allows its users to talk about and share code with friends, classmates and even complete strangers.

You can find many example codes for the Touch Board at:

<https://github.com/BareConductive>

MIDI

MIDI is a standard that describes communication between electronic musical instruments and computers. The advantages of MIDI include the ability to modify notes as they play and to quickly change between instrument sounds.

The Touch Board has an audio processor that we normally use to play back MP3s. However, with a few easy modifications to the board, it can play back audio from MIDI data using its inbuilt synthesiser. Unlike touch MP3 mode, this allows us to choose from a bank of instruments and play back several notes

simultaneously. You can turn the Touch Board into a piano, drum kit or even a clarinet if you want to.

The Touch Board can also be connected to a computer via USB to control music programs such as Ableton Live or Garage Band. These programs do the synthesis for us, enabling more sophisticated outputs. In addition to notes, this also allows us to pass proximity data as MIDI “control change” messages — a bit like turning a control knob or moving a fader up and down. When using the Touch Board, this means you can create sophisticated custom instrument to your own design.

PROGRAMMING

Just like sensors, code is hidden all around us. In fact, it's code that gives sensors instructions on what to do when they detect an input. Every smart phone, website, computer, microwave or computer game needs code to make it work.

Programming is the act of creating code. It involves typing commands to a computer to tell it exactly what to do.

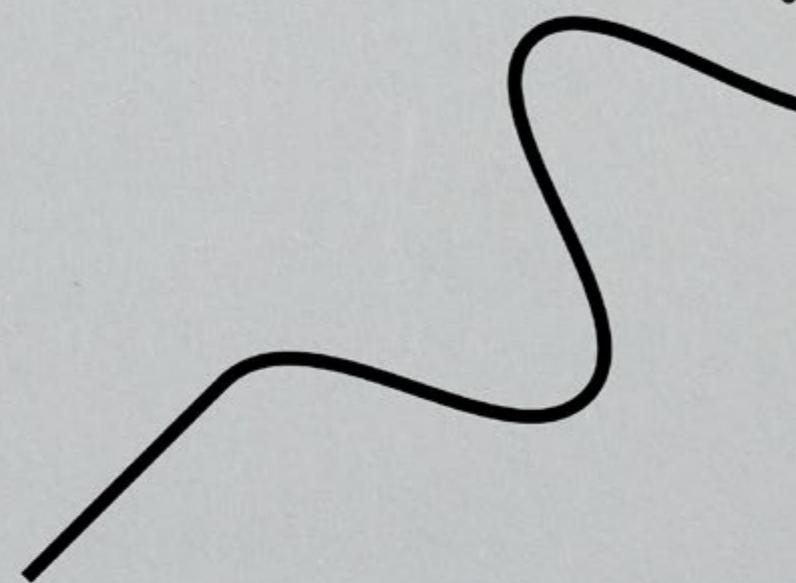
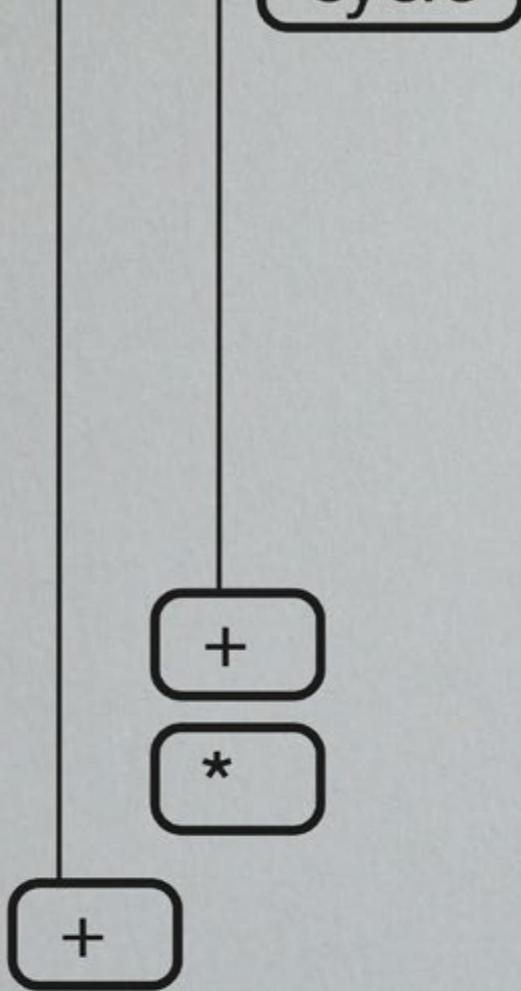
There are many computer languages used for programming. The Touch Board uses the Arduino Integrated Development Environment (Arduino IDE). The IDE works with any Arduino-compatible board, and allows you to write your code in a text box,

which is then uploaded to your board to tell it what to do. The advantage of Arduino is that it benefits from a large community of users who share code to help build on each others projects.

SENSOR

In the broadest definition, a sensor is an object whose purpose is to detect changes in its environment, which could be light, pressure, touch, heat, sound, moisture, and motion among other things. The sensor then provides an output that we can detect electronically. For example, a light sensor could detect the sun rising and trigger a system to open the blinds in a bedroom.

The Touch Board has 12 sensors that can detect changes in capacitance caused by touch or proximity (distance). So it can translate touch or distance into any output defined by you.



bareconductive.com

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