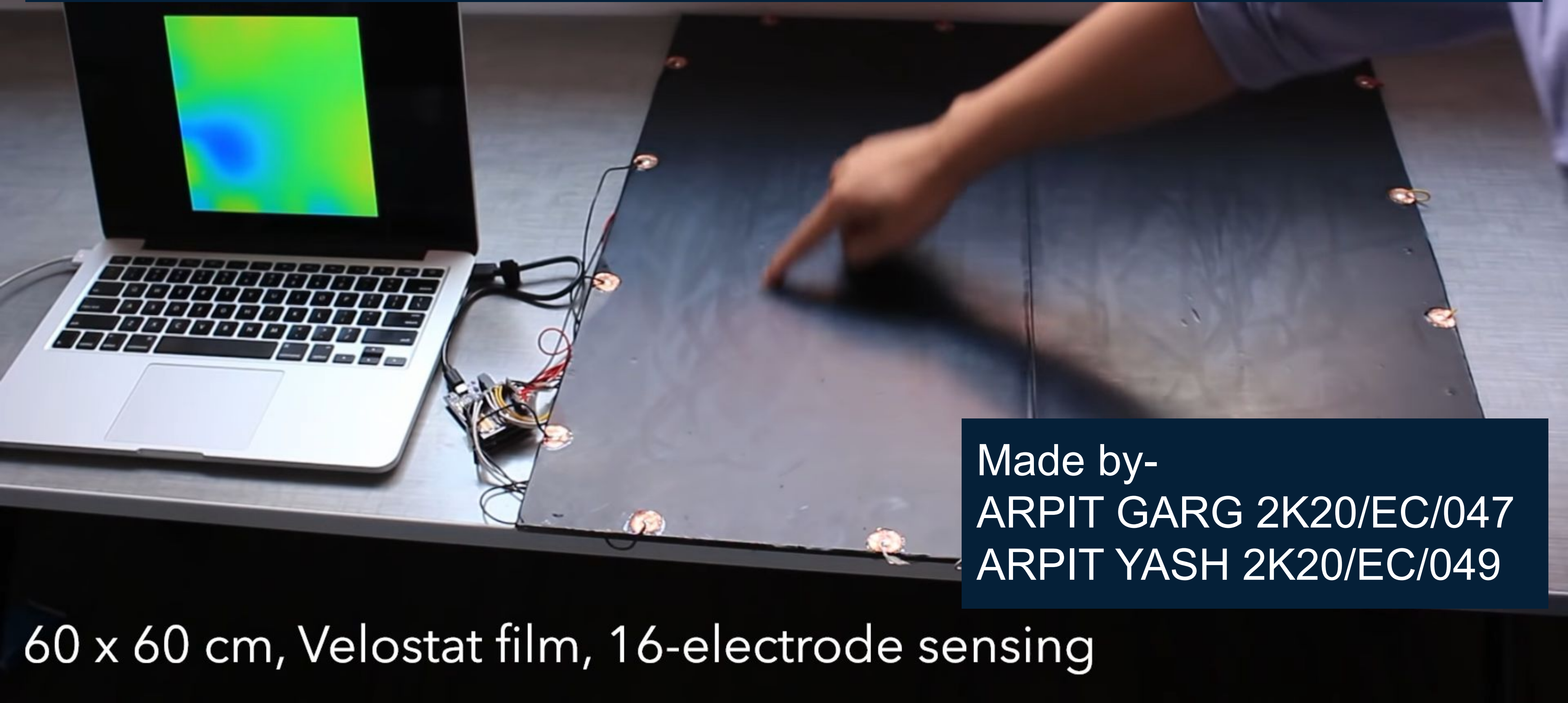
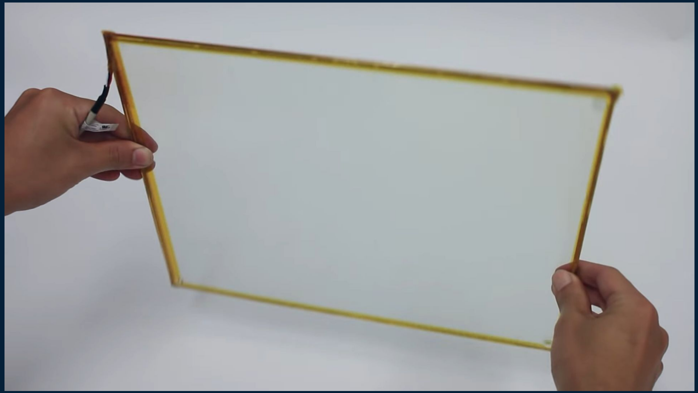
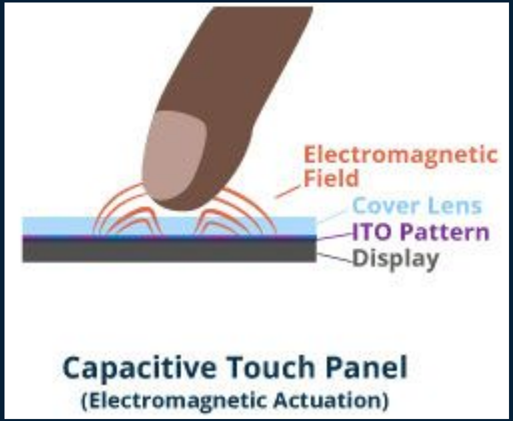
MAKING TOUCHPAD OUT OF ANYTHING:
Low-Cost Touch Sensing Using Electric Field Tomography



Made by-
ARPIT GARG 2K20/EC/047
ARPIT YASH 2K20/EC/049

PROBLEM WITH CURRENT TECHNOLOGIES:
(CAPACITVE SENSORS)





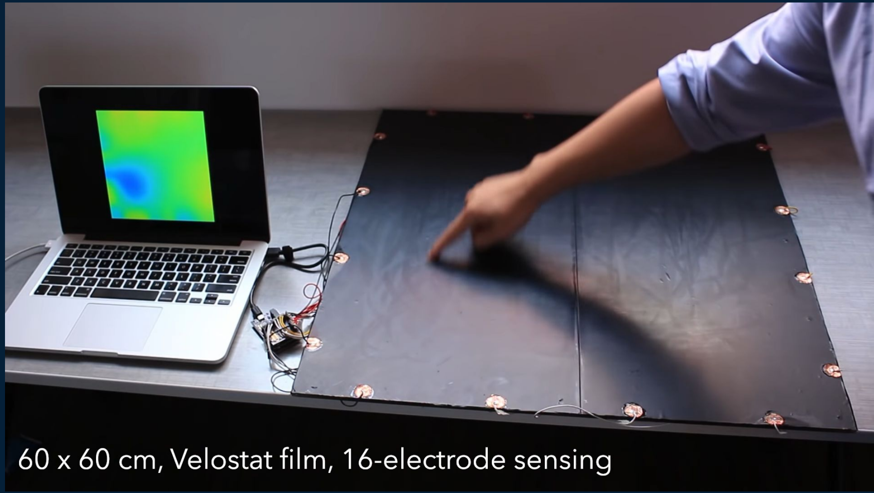
Today’s touchscreen technologies are generally manufactured on a rigid substrate.
For example, projective capacitive sensing, like that used in contemporary smartphones, uses a multi-layered, row-column matrix most often deposited onto glass. Due to its non-mechanical nature, capacitive sensing is a powerful and popular technique for prototyping or retrofitting touch input.

But due to this most touch panels are relatively small and flat. In cases where irregular shapes or large areas have been made touch sensitive, the price tag is often substantial – touchscreens above 75” typically cost thousands of dollars. This high cost and inflexibility has limited touch interaction from being adopted by a wider array of everyday objects, despite touch being an intuitive and popular input modality.

Proposed Technique

Current touch input technologies are best suited for small and flat application and are too expensive to scale to large surfaces, such as walls and furniture, and cannot provide input on objects having irregular and complex geometries, such as tools and toys.

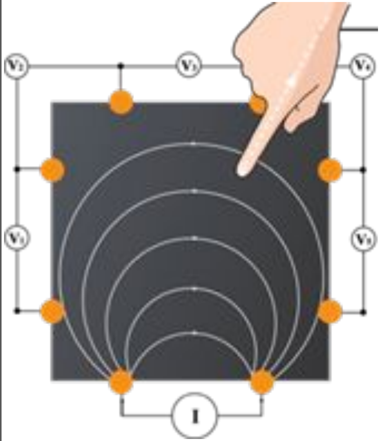
This is a low-cost and versatile sensing technique that enables touch input on a wide variety of objects and surfaces, whether small or large, flat or irregular. This is achieved by using electric field tomography in concert with an electrically conductive material, which can be easily and cheaply added to objects and surfaces. This technique is compatible with commonplace manufacturing methods, such as spray/brush coating, vacuum forming, and casting/molding – enabling a wide range of possible uses and outputs.



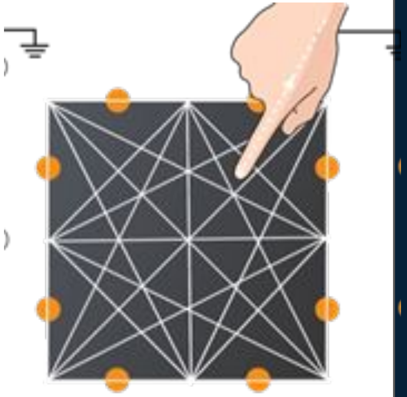
SENSING PRINCIPLE

It requires objects to have a conductive medium further augmented with electrodes placed around the periphery of the desired interactive area. With this configuration, it inserts a small AC current between a pair of adjacent electrodes creating an electric field in the conductive medium. The voltage difference is then measured at all other adjacent electrodes pairings. This process repeats for all combinations of current-projecting and voltage-measuring pairs, resulting in a mesh of cross-sectional measurements.

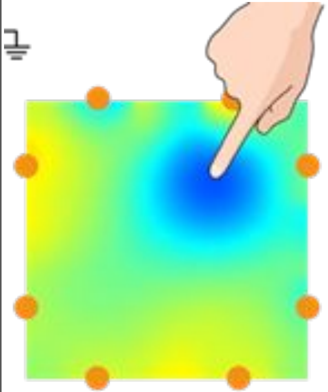
This approach relies on the fact that a grounded object, such as a user’s finger, will shunt some current to ground when it encounters an electric field through capacitive coupling. This current is very small, comparable to that induced by capacitive touch-screens found in smartphones. However, this shunting distorts the electric field, characteristically altering the voltages measured at receiver pairs. We can then use our cross sectional measurements to recover the location of the shunt point.



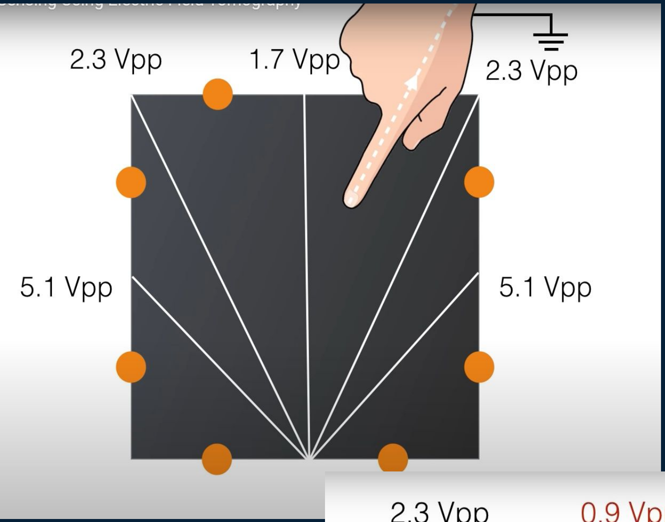
Left: we insert current from one pair of electrodes and measure voltage from other pairs.

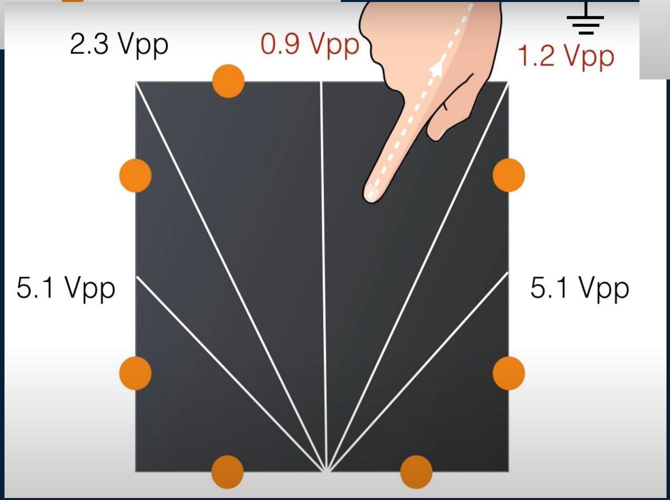


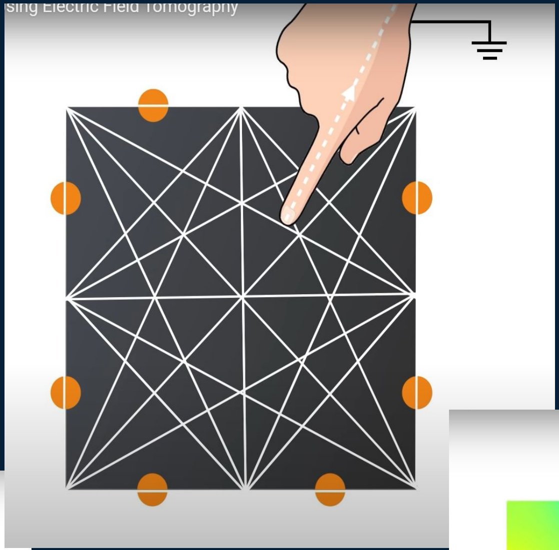
Center: A mesh of cross-sectional measurements.

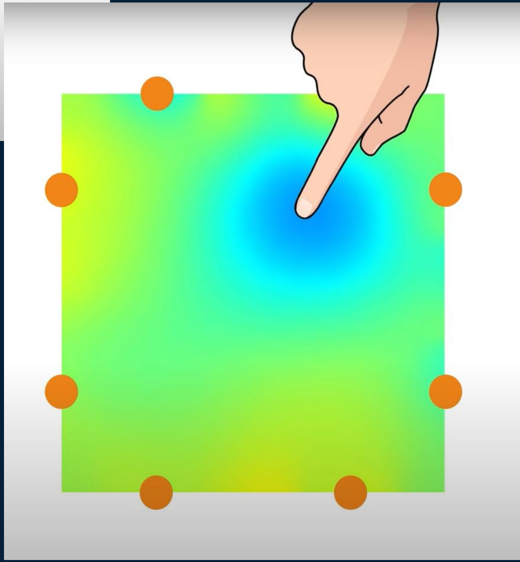


Right: A reconstructed 2D touch-sensing image. Blue indicates low current density.

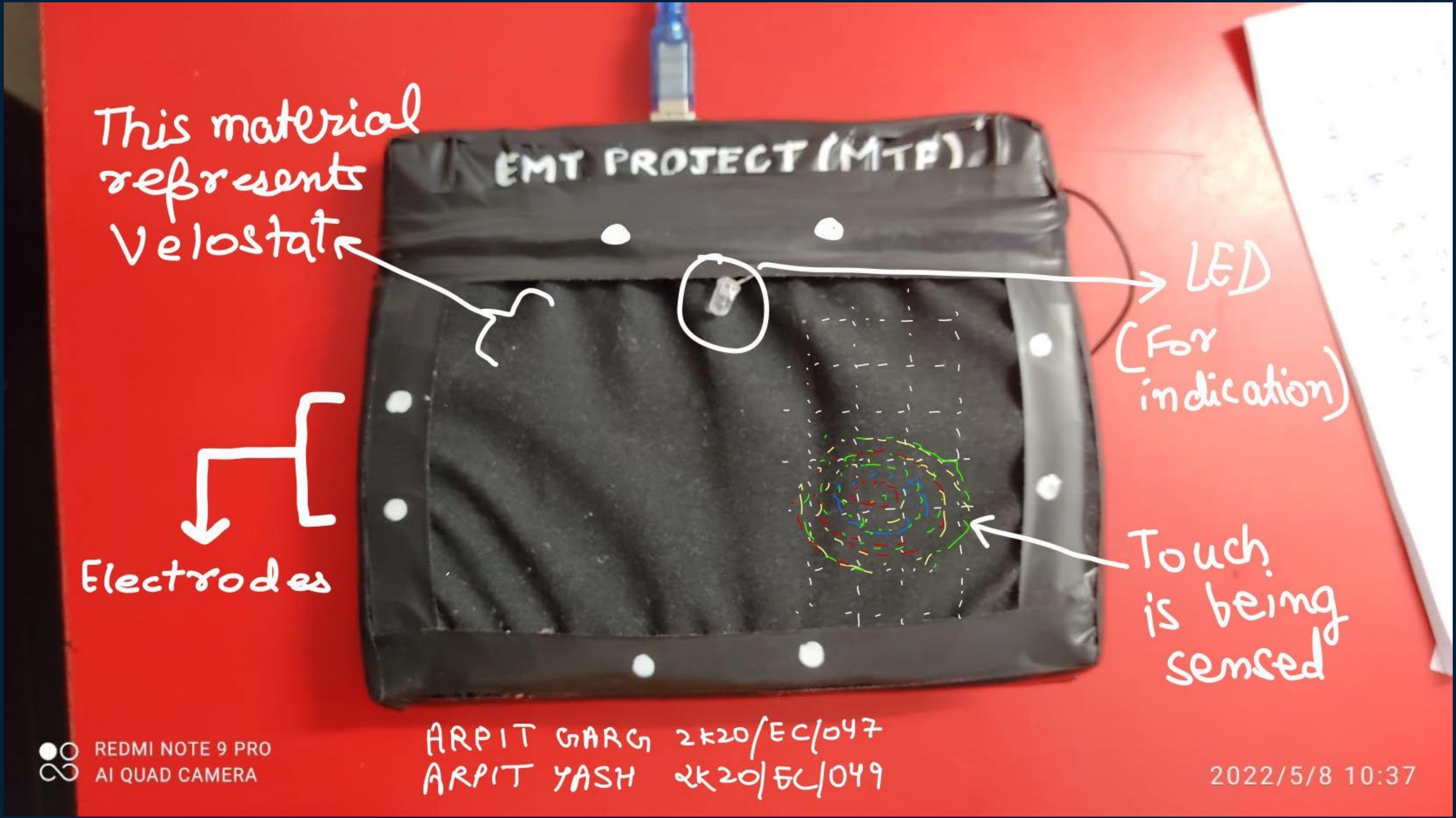

2.3 Vpp
1.7 Vpp
2.3 Vpp
5.1 Vpp
5.1 Vpp


2.3 Vpp
0.9 Vpp
1.2 Vpp
5.1 Vpp
5.1 Vpp


Electric Field Tomography

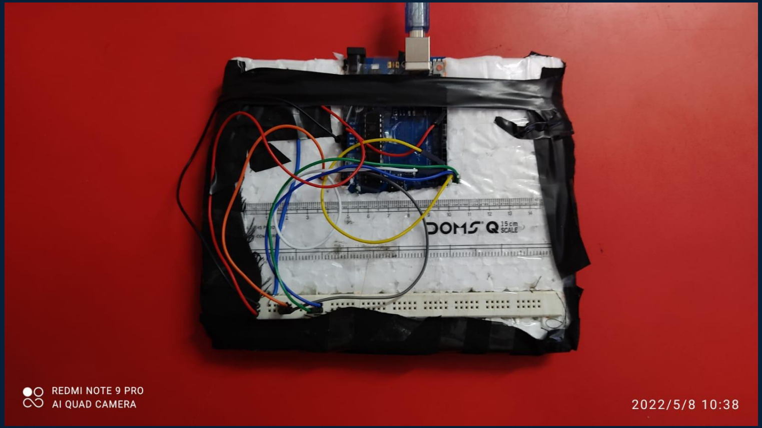


HARDWARE IMPLEMENTATION



WORKING OF OUR PROJECT

In our hardware we have taken help of adruino and capacitive touch sensor to make a prototype of the project , what happens is that when someone touches the black cloth (representing velostat) the capacitive touch sensor under it senses the touch and sends the signal to adruino(This process represents the tomography sensing), and then adruino does the work according to the program , for example in our case we have programmed it to “spacebar” and other half of the touchpad is set to light up the led , the following video is shown in the project report.



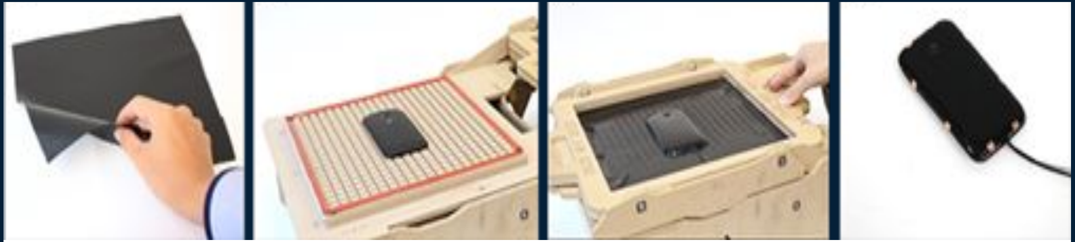
APPLICABLE MATERIALS:

Among many compatible materials, we sought low-cost examples with four key properties:
1) compatible electrical resistivity
2) non-toxicity
3) applied without exotic equipment or facilities
4) readily accessible

Example Solid Materials
Compatible material is Velostat, a carbon-loaded polyolefin sheet/film made by 3M. Bulk plastics, such as ABS and Polycarbonate, are widely available in mildly conductive formulations.

Example Pliable Materials
Playdoh is also compatible ,using it users can shape objects with their bare hands and then make them interactive.

Example paint
we use a carbon conductive paint, which is intended for electrostatic discharge and RF shielding uses.



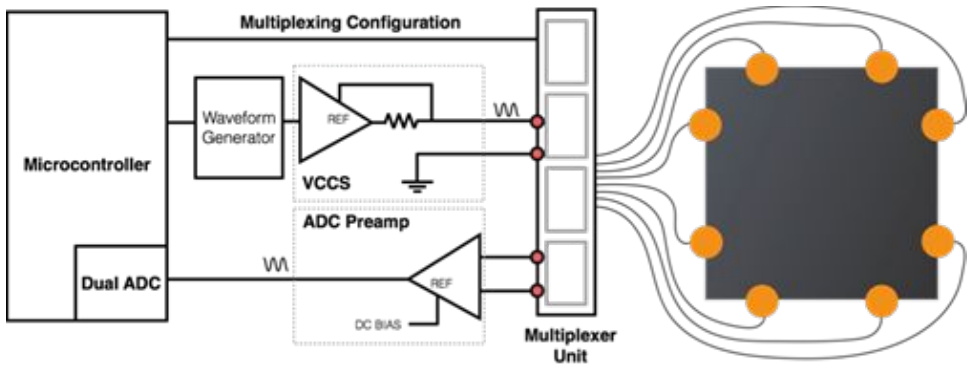
Velostat can be vacuum-formed, as seen in this phone enclosure example.

Carbon sprayed (A) an off-the-shelf toy (B) to make it interactive.

IMPLEMENTATION

Electrodes: Once an object has been created or coated with a compatible conductive material, it must then be instrumented with electrodes around the periphery of the intended interactive region.

Multiplexing: A pair of 32-to-1 multiplexers connect the VCCS terminals to two electrodes, forming the current-projecting electrode pair.



A schematic view of our system with e.g., 8 electrodes

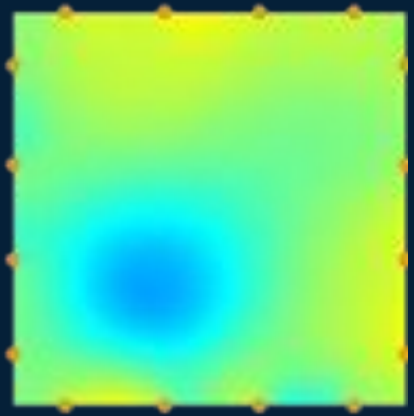
Data Acquisition: After our board selects the appropriate electrodes using its multiplexers. The board then collects multiple samples for a root-mean-square (RMS) computation. This constitutes a single measurement.

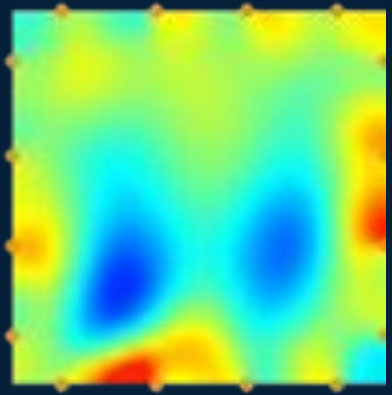
The board then moves to the next voltage-measuring electrode pair, reconfiguring its multiplexers accordingly. After collecting all measurements for the current-projecting configuration, the board then moves to the next current projecting pair and repeats the above procedure. Once it completes one full frame of measurements, the board sends the values for further processing.

TOUCH TRACKING

We can developed our finger-tracking pipeline using a fully realized tomographic reconstruction, to which we applied standard computer vision “blob” tracking techniques. Specifically, we can use a single step Gauss method to produce our tomographic reconstruction.

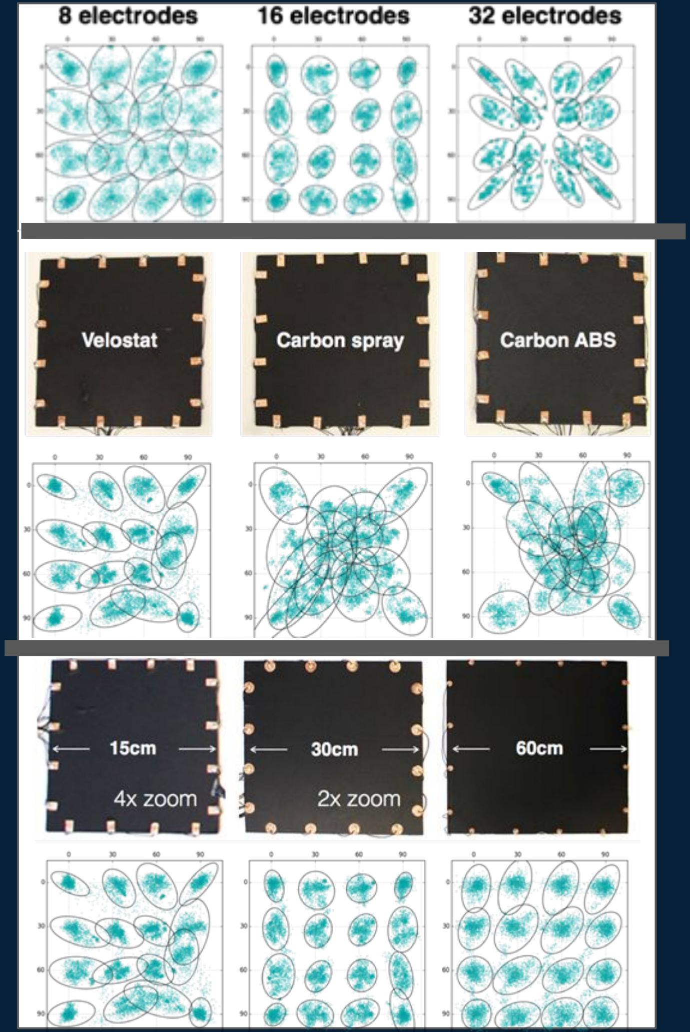
This approach is capable of high accuracy and even multi- touch segmentation. Machine learning offers a robust and practical alternative, one that offloads much of this variability and complexity from users to computers. We can model an object’s geometry, users can perform a simple one-time calibration on the object itself, from which machine learning models can be initialized.





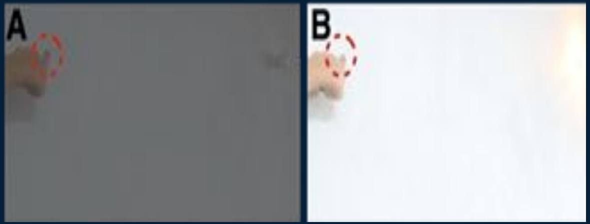
It was found that this method is sensitive to small fabrication/manufacturing variances, such as electrode size, adhesion, and conductive coating thickness.

1. Intuitively, we expected **higher electrode counts** to produce a finer mesh of cross-sectional measurements. A shorter electrode separation means that the electric field does not project as far into the conductive medium, which reduces the signal-to-noise ratio(SNR).
2. There was no statistically significant differences between three **surface geometries.**
3. Encouragingly, spray paint and bare performed equally well, suggesting some **coatings** are immediately compatible
4. Interestingly, we found that larger **surfaces** tend to have more linear regression results, though there was no significant difference.



APPLICATION

This Electrick-augmented steering wheel can track hand location and gestures.



A user can turn on/off a light by tapping the wall.

In this interactive topographical map, touching different regions launches local information

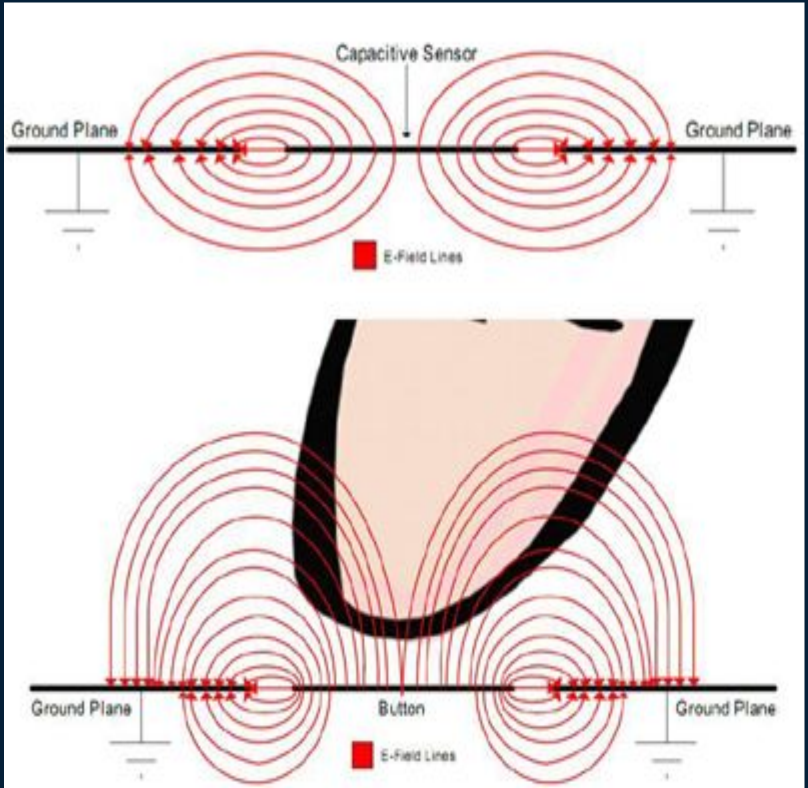
A Play-doh snowman is made interactive.

A guitar with dynamically configurable controls.

Stickers can be placed (A) and bound (B) to laptop functions (C), creating press-able shortcuts (D).

Why better ?

- Works on uneven surfaces
- Can be used for large scale surfaces
- a low-cost and versatile touch sensing technique
- can be used to bring touch interactivity to rapidly prototyped objects, including those that are 3D printed
- Enables touch on nearly anything
- accurately track both discrete and continuous touch input under various test conditions, materials, shapes and sizes



DISADVANTAGES

It requires bigger sensor ground planes which have stronger capacitive coupling, and thus bigger shunting current and SNR.
Environmental electromagnetic noise, from e.g., fluorescent lights, running appliances and power lines, can affect tracking accuracy. Not only does the conductive object act like an antenna, but so does the human body, which upon touch, introduces more noise.

CONCLUSION

We have presented it as a low-cost and versatile touch sensing technique that can be scaled to large surfaces and irregular geometries. It can be used to bring touch interactivity to rapidly prototyped objects. It can accurately track both discrete and continuous touch input under various test conditions, materials, shapes and sizes. It is also is robust over time and across users. We believe this work can bring touch interactivity to new classes of objects, as well as enable designers to rapidly prototype objects with innate interactive capabilities