Michigan Technological University

CS5760 - HUMAN COMPUTER INTERACTION AND USABILITY TESTING

TOPIC PAPER : GESTURE RECOGNITION ON MOBILE DEVICES

-Soham Sheth
-Graduate Student
-College of Computing
-Michigan Technological University
-ssheth1@mtu.edu

Background of mobile Devices

1981

1992

2001

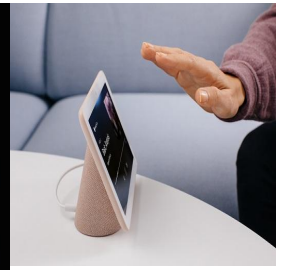
2011

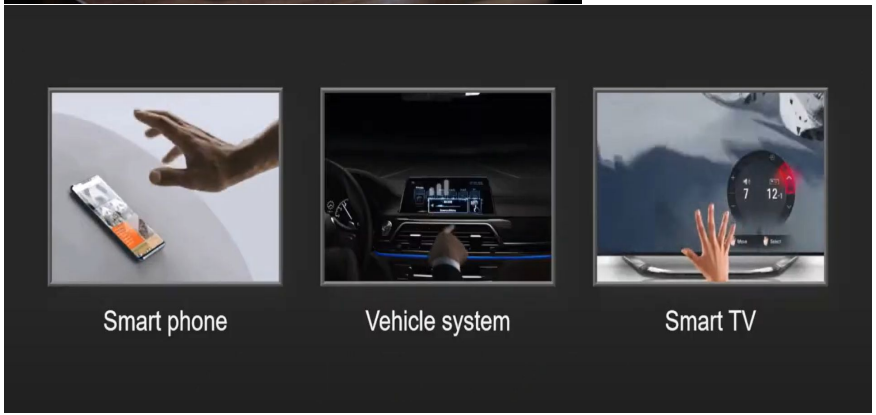
2020

TOUCH-FREE (LESS) DEVICES
In Air Gesture Control

Gesture Recognition on different devices

- Vehicle System
- Smart TV
- Smart Watch
- Video Games
- Smart Phone





Gesture Control using Hardware Modifications on Mobile devices

Hardware Devices Used and their problems

- Depth Camera
  [Huawei Mate 40]
- mmWave Radar
  [Google Pixel 4]
- Wi-Fi

Problems

1. Privacy Concerns
2. Background Noise

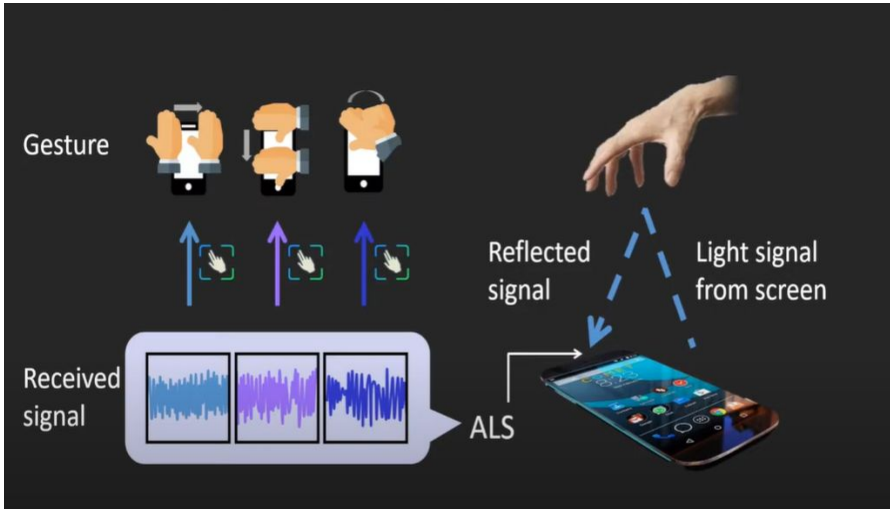
ALTERNATIVE OPTION (**Ambient Light Sensor**)

ALS (Ambient Light Sensor) can detect gestures on a mobile screen by measuring the changes in light intensity caused by the user's hand movements. The ambient light sensor is typically located on the front of the device, near the screen, and is used to adjust the brightness of the screen based on the surrounding lighting conditions.

The ALS captures this change in light intensity and converts it into an electrical signal. The signal is then processed by the device's software to determine the type of gesture that has been performed.

WORKING AND ADVANTAGES

The ambient light sensor (ALS) in a mobile device is typically located on the front of the device, usually near the top. The sensor consists of a photodiode that measures the amount of ambient light entering the sensor. This data is then processed by the device's software to adjust the display's brightness and color temperature to match the surrounding lighting conditions.

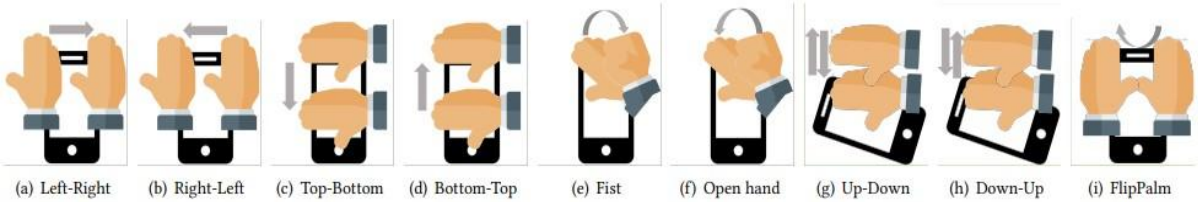


Advantages :

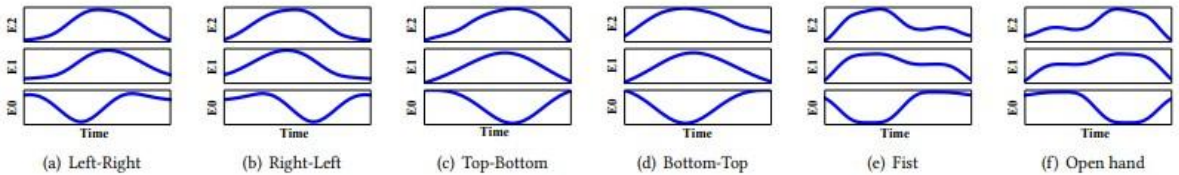
- ALS only captures ambient light intensity, which contains minimal sensitive information.
- ALS is available in all the devices we don’t need any hardware modifications

Gestures Recognition Using ALS

To recognize air gestures using ALS in a mobile device, a separate transmitter and receiver system is not required. Instead, the device's ALS can be used in combination with other sensors, such as cameras and infrared sensors, to capture the necessary data to recognize and classify hand air gestures



Gestures Recognition using ALS



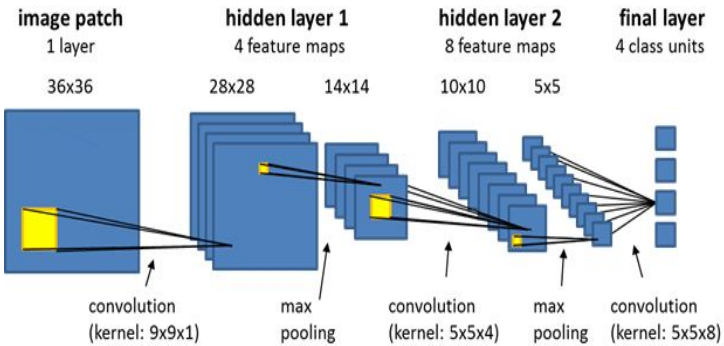
Signal patterns for several gestures

Machine Learning Algorithms

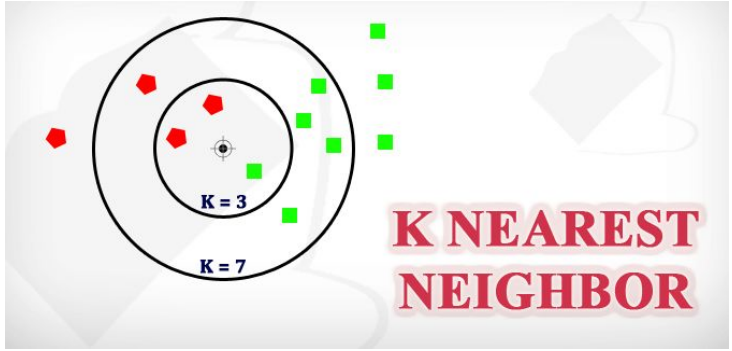
The gesture recognition algorithms in the device's software can be trained using machine learning techniques, which involve training the software to recognize patterns in the data captured by the sensors that correspond to specific gestures.

Different Machine Learning Algorithms used for Gesture Recognition

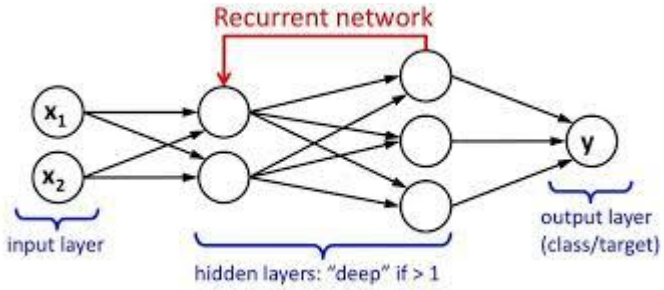
- Convolutional Neural Networks (CNNs):
- Recurrent Neural Networks (RNNs):
- Support Vector Machines (SVMs):
- Hidden Markov Models (HMMs):
- K-Nearest Neighbors Algorithm(KNN)



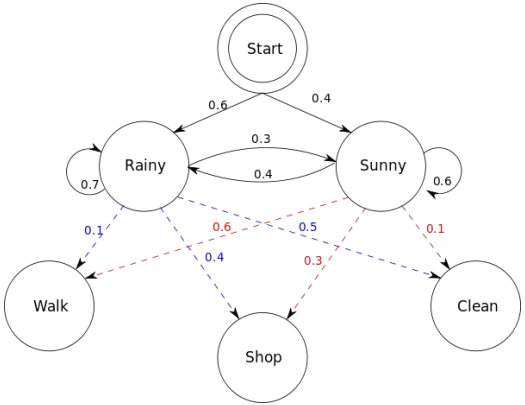
CONVOLUTIONAL NEURAL NETWORKS



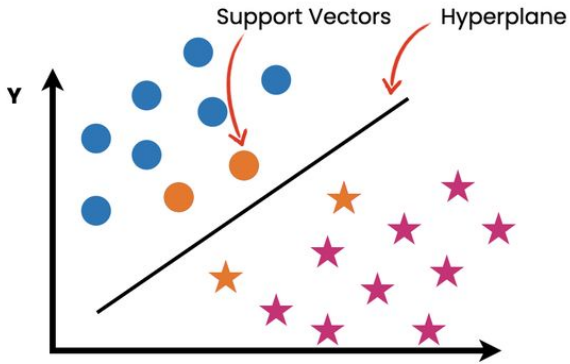
K- Nearest Neighbor



Recurrent Neural Networks



Hidden Markov Model



SUPPORT VECTOR MACHINE

How to decide which is better algorithm ?
Evaluation Metrics

$$Accuarcy = \frac{TP + TN}{TP + TN + FP + FN}$$

$$Precision = \frac{TP}{TP + FP}$$

$$Recall = \frac{TP}{TP + FN}$$

$$F1 - Score = \frac{2 * Precision * Recall}{Precision + Recall} = \frac{2TP}{2TP + FP + FN}$$

Conclusion

We can support gesture recognition on old hardware without changing the hardware with the help of Ambient Light Sensor (ALS) and some machine learning algorithms

+

There is more experimental work required for finalizing and implementing this technology in our daily usage

=

The combination of sensor data and machine learning algorithms has enabled mobile devices to accurately recognize and classify hand air gestures, allowing for more intuitive and efficient interaction with mobile devices without any modification in the hardware part and which are more safe to implement.

REFERENCES

[1]2021. Zimo Liao, Zhicheng Luo, Qianyi Huang, Linfeng Zhang, Fan Wu, Qian Zhang, and Yi Wang. SMART: screen-based gesture recognition on commodity mobile devices.

[2] 2018. Introduction and use of Android Framebuffer. https://kaustav.space/2018-09-22/introduction-to-android-framebuffer

[3] 2019. APDS-9253-001. https://docs.broadcom.com/docs/APDS-9253-001-DS

[4] 2019. Google project soli. https://www.google.com/atap/project-soli/

[5] 2021. CIE 1931 color space. https://en.wikipedia.org/wiki/CIE_1931_color_space

[6] 2021. Google pixel 4. https://store.google.com/product/pixel_4a

[7] 2021. Huawei mate30. https://consumer.huawei.com/en/phones/mate30/

[8] 2021. Leap Motion,. https://www.leapmotion.com/

[9] 2021. LG G8 ThinQ. https://www.lg.com/us/cell-phones/lg-LMG820UM1-attg8-thinq

[10] 2021. Measuring Device Power. https://source.android.com/devices/tech/power/ device

THANK YOU