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Gesture Recognition and Control

Part 3 – WiFi Oriented Gesture Control & its application

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Abstract
This Exploratory Survey paper explore the basic principle behind WiFi oriented Gesture Control System. The paper briefly provided the literature review about this latest technology. This technology having vast applications in real time situation like in Gaming, Home automation, Medicine for disabled & latest electronic gadgets. The researcher from University of Washington has done a milestone work for this technology. It will be expected that in 2020 era, the WiFi based Gesture Control & Recognition system replace all other Man-Machine interface methods.

Key Words: WiFi Signals & System, Mapping, Decoding, UW, WiSee, LCD Matrix Schematic, uTouch, MIMO

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Introduction

Computer scientists from University of Washington have developed gesture-recognition technology that brings the filmy fiction a step closer to reality. Researchers have shown it's possible to leverage Wi-Fi signals around us to detect specific movements without needing sensors or cameras on the human body. By using Wi-Fi router and a few wireless devices in the living room, users could control their electronics and household appliances from any room in the home with a simple gesture. "This is repurposing wireless signals that already exist in new ways," said lead researcher Shyam Gollakota [1], a UW assistant professor of computer science and engineering. "You can actually use wireless for gesture recognition without needing to deploy more sensors."

1. UW Principle

The concept is similar to Xbox Kinect [2,8] (a commercial product that uses cameras to recognize gestures), but the UW technology is simpler, cheaper and doesn't require users to be in the same room as the device they want to control. That's because Wi-Fi signals can travel through walls and aren't bound by line-of-sight or sound restrictions. The UW researchers built a "smart" receiver device that essentially listens to all of the wireless transmissions coming from devices throughout a home, including smartphones, laptops and tablets. A standard Wi-Fi router could be adapted to function as a receiver. When a person moves, there is a slight change in the frequency of the wireless signal. Moving a hand or foot causes the receiver to detect a pattern of changes known as the Doppler frequency shift. This new technology uses wireless signals that uniquely bounces off a human body making various gestures then recognized by the receiving gesture recognition software that can be tuned to register minimal doppler shifts (transformed into a narrowband pulse for possible detection) in the emitted frequency (Fig 1) that can be mapped to specific gestures.

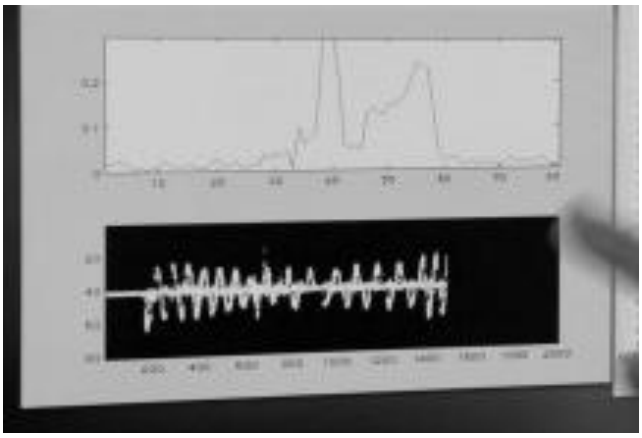

Fig 1 [2]

These frequency changes are very small – only several hertz – when compared with Wi-Fi signals that have a 20 megahertz bandwidth and operate at 5 gigahertz. Researchers developed an algorithm to detect these slight shifts. The technology also accounts for gaps in wireless signals when devices aren't transmitting. The technology can identify nine different whole-body gestures, ranging from pushing, pulling and punching to full-body bowling. The researchers tested these gestures [2] with five users in a two-bedroom apartment and an office environment. Out of the 900 gestures performed, WiSee accurately classified 94 percent [2] of them. "This is the first whole-home gesture recognition system that works without either requiring instrumentation of the user with sensors or deploying cameras in every room," said Qifan Pu, a collaborator and visiting student at the UW.

2. System Architecture

The system requires one receiver with multiple antennas. Intuitively, each antenna tunes into a specific user's movements, so as many as five people can move simultaneously in the same residence without confusing the receiver.

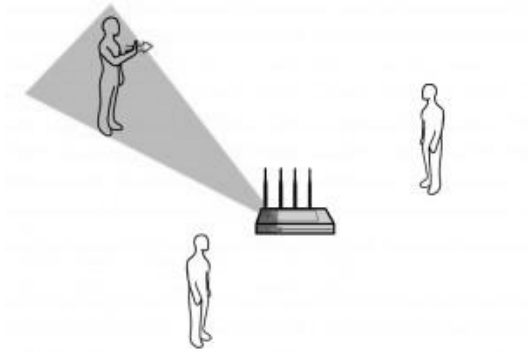

Fig 2 [2]

WiSee technology [3] uses multiple antennas to focus on one user to detect the person's gesture. WiSee therefore is claimed to be used anywhere in a room or in a house regardless of walls hindering the line of sight and does not require a specific device or a camera to register the gesture visually. If there are more than one gesture user in a room, multiple wifi antennas are used and decoded. Gestures enable a whole new set of interaction techniques for always-available computing embedded in the environment. For example, using a swipe hand motion in-air, a user could control the music volume while showering, or change the song playing on a music system installed in the living room while cooking, or turn up the thermostat while in bed. Such a capability can enable applications in diverse domains including home-automation, elderly health care, and gaming.

Signals used in Wifi do not require line-of-sight and can traverse through walls, very few signal sources need to be present in the space (e.g., a Wi-Fi AP and a few mobile devices in the living room). WiSee works by looking at the minute Doppler shifts and multi-path distortions that occur with these wireless signals from human motion in the environment.

WiSee leverages the property of Doppler shift [3], which is the frequency change of a wave as its source moves relative to the observer. A user moving his hand away from the receiver results in a negative Doppler shift. While moving the hand towards the receiver results in a positive Doppler shift. Human hand gestures result in very small Doppler shifts that can be hard to detect from typical wireless transmissions (e.g.,Wi-Fi). Specifically, since wireless signals are electromagnetic waves that propagate at the speed of light (c m/sec), a human moving at a speed of v m/sec, results in a maximum Doppler shift of 2f c v, where f is the frequency of the wireless transmission [3]. Thus, a 0.5 m/sec gesture results in a 17 Hz Doppler shift on a 5 GHz Wi-Fi transmission. Typical wireless transmissions have orders of magnitude higher bandwidth (20 MHz for Wi-Fi). Thus, for gesture recognition, we need to detect Doppler shifts of a few Hertz from the 20 MHz Wi-Fi signal. At a high level, WiSee addresses this problem [3] by transforming the received signal into a narrowband pulse with a bandwidth of a few Hertz. Home may have multiple people who can affect the wireless signals at the same time. WiSee uses the MIMO capability that is inherent to 802.11n, to focus on gestures from a particular user.

In multi user environment at home, user gains control of the interface by performing a specific gesture pattern. In WiSee the target human performs a repetitive gesture, which we use as that person's preamble. A WiSee receiver utilize this preamble to estimate the MIMO [3] channel that maximizes the energy of the reflections from the user. Once the receiver locks on to this channel, the user performs normal (non-repetitive) gestures that the receiver classifies.

A WiSee-enabled Wi-Fi AP [3] acting as a receiver and a couple of mobile devices acting as transmitters, WiSee can enable whole-home gesture recognition. Using a 5-antenna receiver and a single-antenna transmitter, WiSee can successfully perform gesture classification, in the presence of three other users

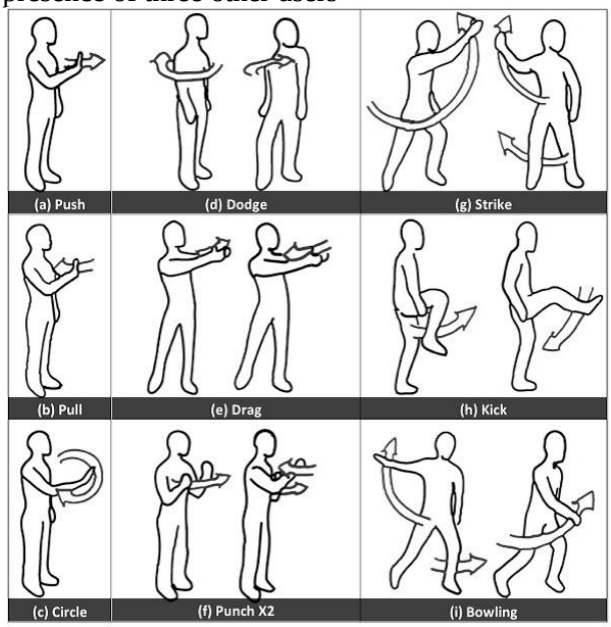

Fig 3 [3,6,7]

The classification accuracy reduces as we further increase the number of interfering users. This is a limitation of WiSee. The framework for WiSee is shown in fig 4.

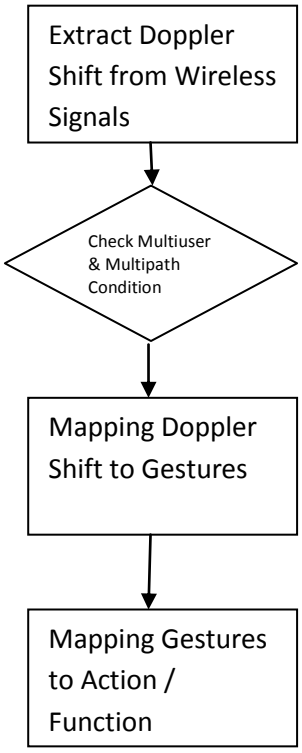

Fig 4 : WiSee Framework

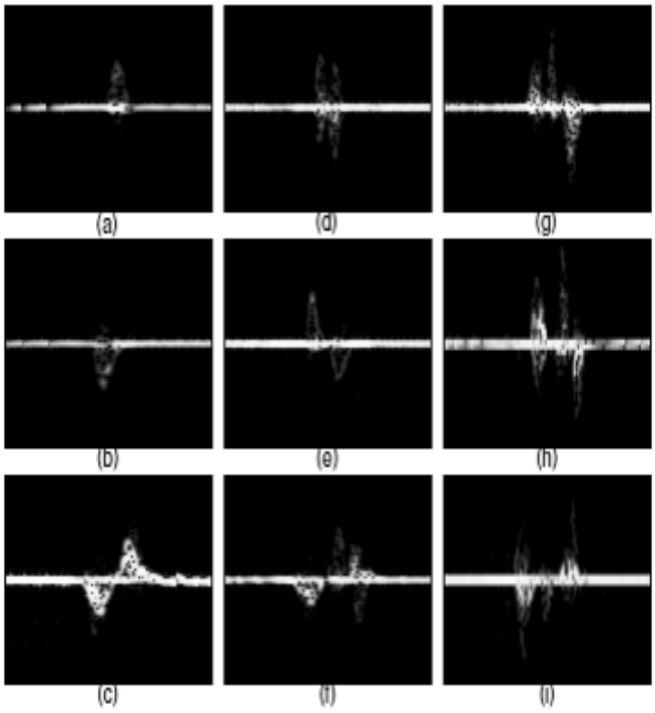

Fig 5 [3,6]

Our results in a 2-bedroom apartment show that WiSee can extract a rich set of gesture information from wireless signals and enable whole-home gesture recognition using only two wireless sources placed in the living room.

3. Wifi oriented Gesture Control System based Application – "uTouch" – converting normal LCD into Gesture controlled LCD.

Chen, Cohn, Gupta & Patel from University of Washington [5] reveal the remarkable applicability through uTouch (a solution) for enabling touch interaction on existing non-touch LCD screens require adding additional sensors to the interaction surface. A system that detects and classifies touches and hovers without any modification to the display, and without adding any sensors to the user.

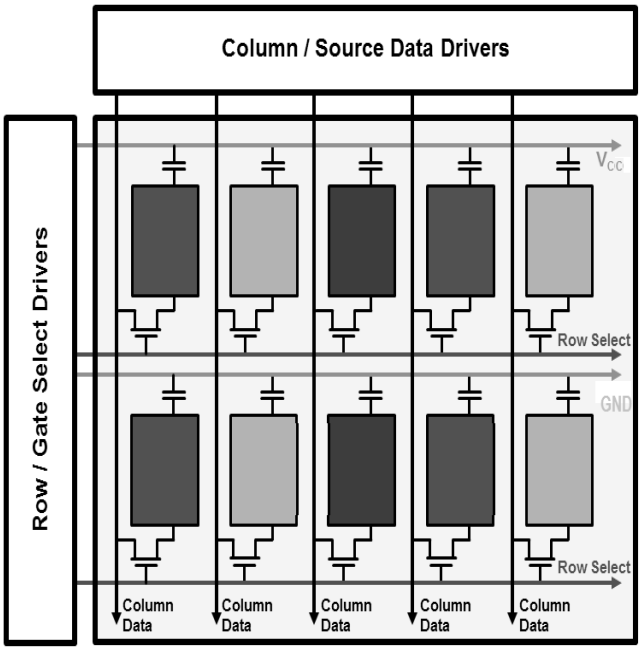

Fig 6: Block diagram of LCD Panel matrix segment [5]

As the screen is touched, the charge in capacitor vary, which results in current variation, finally an EMI produced. That EMI can be superimposed on power and travel through power line. That EMI can be sensed around Power line.

This approach utilizes existing signals in an LCD (as shown in fig 6) that are amplified when a user brings their hand near or touches the LCD's front panel. These signals are coupled onto the power lines, where they appear as electromagnetic interference (EMI) which can be sensed using a single device connected elsewhere on the power line infrastructure.

Fig 7: Mapping of Gestures [5]

The energy content of produced EMI depends upon the way of touch. Hence the energy level can be mapped in different gesture as shown in fig 7. Such type of phenomenon can be used in variety of applications [7] such as Automation Control, Gaming, Electronic Multimedia devices (like TV, Music system) etc.

Conclusion

Present WiSee, a novel Gesture Recognition System, utilizes wireless signals to enable whole-home sensing and recognition of human gestures. Since wireless signals do not require line-of-sight and can traverse through walls, WiSee can enable whole home gesture recognition using few signal sources. WiFi oriented GCS is revolutionary technology and will replace present Man-machine interface system completely in coming 2020 era. The demonstration of uTouch by researchers proves the credibility of this technology.

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