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WI-FI TECHNOLOGY AROUND THE WORLD

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ABSTRACT
Wi-Fi signals are typically information carriers between a transmitter and a receiver. In this thesis, we show that Wi-Fi can also extend our senses, enabling us to see Moving objects through walls and behind closed doors. For example, we can identify the number of people in a closed room and their relative locations. We can also identify simple gestures made behind a wall. Further, by combining a sequence of gestures, a human can communicate messages to a wireless receiver without carrying any transmitting device. The thesis introduces two main innovations. First, it shows how one can use MIMO interference nulling to eliminate reflections off static objects and focus the receiver on a moving target. Second, it shows how one can track a human by treating the motion of a human body as an antenna array and tracking the resulting RF beam. We demonstrate the validity of our design by building it into USRP software radios and testing it in office buildings

1. INTRODUCTION
Can Wi-Fi signals enable us to see through walls, For many years, humans have Fantasized about X-ray vision and played with the concept in comic books and sci-fi movies. This thesis explores the potential of using Wi-Fi signals and recent advances in MIMO communications to build a device that can capture the motion of humans behind a wall and in closed rooms. Law enforcement personnel can use the device to avoid walking into an ambush, and minimize casualties in standoffs and hostage situations. Emergency responders can use it to see through rubble and collapsed structures. Ordinary users can leverage the device for gaming, intrusion detection, privacy-enhanced monitoring of children and elderly, or personal security when step- ping into dark alleys and unknown places. To address these limitations, an initial attempt was made in 2012 to use Wi-Fi to see through a wall However, to mitigate the flash effect, this past proposal needs to install an additional receiver behind the wall, and connect the receivers behind and in-front of the wall to a joint clock via wires .

2. SEEING THROUGH WALLS WITH WI-FI
The objective of this thesis is to enable a see-through-wall technology that is low- bandwidth, low-power, compact, and accessible to non-military entities. To this end, the thesis introduces Wi-Fi2, a see-through-wall device that employs Wi-Fi signals in the 2.4 GHz ISM band.Wi-Fi limits itself to a 20 MHz-wideWi-Fi channel, and avoids ultra-wideband solutions used today to address the flash effect. It also disposes of the large antenna array, typical in past systems, and uses instead a smaller 3-antenna MIMO radio. O, multiple antenna systems can encode their transmissions So that the signal is nulled (i.e., sums up to zero) at a particular receive antenna. MIMO systems use this capability to eliminate interference to unwanted receivers. In contrast, we use nulling to eliminate reflections from static objects, including the wall.

Specifically, a Wi-Fi device has two transmit antennas and a single receive antenna. Wi-FI operates in two stages. In the first stage, it measures the channels from each of its two transmit antennas to its receive antenna. In stage 2, the two transmit antennas Use the channel measurements from stage 1 to null the signal at the receive antenna. Since wireless signals (including reflections) combine linearly over the medium, only Reflections off objects that move between the two stages are captured in stage 2. Reflections off static objects, including the wall, are nulled in this stage. In, Refine this basic idea by introducing iterative nulling, which allows us to eliminate Residual flash and the weaker reflections from static objects behind the wall.

3. RELATED WORK

Through wall radar
There is growing interest in through-wall imaging for about a decade. Earlier work in this area focused on the simulations and modeling. Recently, there are some design implementations tested with moving humans. These past design of systems or devices eliminate the flash effect by doing isolation of the signal reflected off the wall

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from signals reflected off objects behind the wall. This isolation can be achieved in the time domain with the help of very short pulses (less than 1ns). Where the pulse reflected off the wall arrives earlier in time than that reflected off moving objects behind it due to the distance travelled.

Gesture-based interfaces

The academic community is also developed some systems capable of identifying human gestures either by using cameras or by placing sensors on the human body. Recent work has also leveraged narrowband signals in the 2.4 GHz range to identify human activities in line-of-sight using micro-Doppler signatures Wi-Fi technology presents the first gesture-based interface that works in non-line-of-sight scenarios, and also through a wall. This technology does not require the human to carry any wireless device or to wear a set of sensors.

Infrared and thermal imaging

They operate by capturing or collecting infrared or thermal energy reflected off the first obstacle in line-of-sight of their sensors.

4. WI-FI OVERVIEW

Wi-Fi technology is a wireless device that captures moving objects behind a wall and door. Wi-Fi has the strategic advantage of Wi-Fi to make through wall imaging relatively low cost, low power, low-bandwidth, and accessible to average users. Wi-Fi uses the Wi-Fi OFDM signals in the ISM band i.e. at 2.4 GHz and typical Wi-Fi hardware. Wi-Fi is basically a 3-antenna MIMO device in which two antennas are used for transmitting and one is for receiving. This also includes directional antennas to focus on the energy toward the wall or room of interest. Its design includes two main components:

- ✓ The first component is used to eliminate the flash reflected off the wall by performing MIMO nulling.
- ✓ The second component is used to tracks the moving object by treating the object itself as an antenna array using a technique called inverse SAR i.e. ISAR. Wi-Fi can be used in one of above two modes. It depends on the user's choice.

5. ELIMINATING THE FLASH

In every through-wall system, the signal reflected off the wall which is nothing but the flash, is much stronger than any signal reflected from objects behind the wall. This is due to the attenuation which electromagnetic signals suffer when penetrating through the dense obstacles. The examples of the one-way attenuation experienced by Wi-Fi signals in construction materials. For example- once the signal is traversed through solid wood door or interior hollow wall, the Wi-Fi signal power is reduced by 6dB and 9dB. As mirrored signal on each the reflection constant because the cross-sectional of object owing to that the particular mirrored signal becomes weaker. Hence, Wi-Fi increases the sensitivity to the reflection of interest by victimization the development of nulling the interference or by power boosting.

Applications

Law enforcement: Law enforcement personal can use the device to avoid walking into an ambush, and minimize causalities in hostage and standoffs situations.

Emergency situations: Emergency responders can use Wi-Fi to see through rubble and collapsed structures.

Smart Sensing: This Wi-Fi technology can be extended to sense motion in different parts of a building and allow automated control of heating or cooling and lighting systems.

Personal Security: Common users can use it for intrusion detection and when stepping into dark alleys and unknown places.

Entertainment: It enables a new dimension for input-output devices in gaming which does not affect on occlusion and works in non-line-of-sight.

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User Interface Design: This technology may also be leveraged in the future to enable the controlling household appliances via gestures, and non-invasive monitoring of children and elderly.

Advantages

- ✓ First advantage is this system uses only one receiver still effectively measures the time it takes for the signals to reflect to calculated the exact location.
- ✓ Second is with low cost Wi-Fi technology system can be utilized in disaster recovery and gaming activities.
- ✓ And lastly Wi-Fi technology, as a gesture-based interface, does not require a line of sight between the user and the device.

6. ELIMINATING THE FLASH EFFECT

Electromagnetic signal produces important attenuation dense obstacles that results in stronger flash signals than the other mirrored signals off the article. Considering the tables on top of within which a method rf attenuation of signal is determined through Wi-Fi signal. For example- once the signal is traveled through interior hollow wall or concrete wall, the Wi-Fi signal power is reduced by 9dB and 18dB. As mirrored signal on each the reflection constant likewise because the cross-sectional of object owing to that the particular mirrored signal becomes weaker .hence, Wi-Fi will increase the sensitivity to the reflection of interest by victimization the development of interference nulling.

Nulling To Remove Flash

Recent advances show that MIMO systems can pre-code their transmissions such that the signal received at a particular antenna is cancelled. Past work on MIMO has used this property to enable concurrent transmissions and null interference. We observe that the same technique can be tailored to eliminate the flash effect as well as the direct signal from the transmit to the receive antenna, thereby enabling Wi-Fi to capture the reflections from objects of interest with minimal interference.

Power Boosting

Simply nulling static reflections, however, is not enough because the signals due to moving objects behind the wall are too weak. Say, for example, the flash effect was 30 to 40 dB above the power of reflections off moving objects. Even though we removed the flash effect, we can hardly discern the signal due to moving objects since it will be immersed in the receiver's hardware noise. Thus, we next boost the transmitted signal power.5 Note that because the channel has already been nulled, i.e., hres == 0. this increase in power does not saturate the receiver's ADC. However, it increases the overall power that traverses the wall, and, hence, improves the SNR of the signal due to the objects behind the wall.

Iterative Nulling

After boosting the transmit power, residual reflections which were below the ADC quantization level become measurable. Such reflections from static objects can create significant clutter in the tracking process if not removed. To address this issue, Wi-Fi performs a procedure called iterative nulling. At a high level, the objective is simple: we need to null the signal again after boosting the power to eliminate the residual reflections from static objects. The challenge, however, is that at this stage, we cannot separately estimate the channels from each of the two transmit antennas since, after nulling, we only receive a combined channel. We also cannot remove the nulling and re-estimate the channels, because after boosting the power, without nulling, the ADC would saturate.

7. EVALUATION OF WI-FI

We built a prototype of Wi-Fi using USRP N210 radios and evaluated it in two office buildings. Our results are as follows:

- ❖ Wi-Fi can detect objects and humans moving behind opaque structural obstructions. This applies to 8″ concrete walls, 6″ hollow walls, and 1.75″ solid wooden doors.
- ❖ A Wi-Fi device pointed at a closed room with 6″ hollow walls supported by steel frames can distinguish between 0, 1, 2, and 3 moving humans in the room. The precisions with which Wi-Fi

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identifies each case, computed over 80 trials with 8 human subjects, are 100%, 100%, 85% and 90% respectively.

- In the same room, and given a single person sending gesture-based messages, Wi-Fi correctly decodes all messages performed at distances equal to or smaller than 5 meters.

The decoding accuracy decreases to 75% at distances of 8 meters, and the device stops detecting gestures beyond 9 meters. For 8 volunteers who participated in the experiment, on average, it took a person 8.8 seconds to send a message of 4 gestures.

- In comparison to the state-of-the-art ultra-wideband see-through-wall radar, Wi-Fi is limited in two ways. First, replacing the antenna array by ISAR means that the angular resolution in Wi-Fi depends on the amount of movement. To achieve a narrow beam, the human needs to move by about 4 wavelengths (i.e., about 50 cm). Second, in contrast to, we cannot detect humans behind concrete walls thicker than 8″. This is due to both the much lower transmit power from our USRPs and the residual flash power from imperfect nulling. On the other hand, nulling the flash removes the need for GHz bandwidth. It also removes clutter from all static reflectors, rather than just one wall. This includes other walls in the environments as well as furniture inside and outside the imaged room. To reduce clutter, the empirical results in past work are typically collected using a personheight standing wall, positioned either outdoors or in large empty indoor spaces. In contrast, our experiments are in standard office buildings with the imaged humans inside closed fully-furnished rooms.

8. ADVANTAGES

- Wi-Fi is relatively a low-power, low-cost, low-bandwidth, and accessible to average users.
- Wi-Fi requires only few MHz of bandwidth and operates in the same range as Wi-Fi. It operates in ISM band.
- Wi-Fi can perform through-wall imaging without access to any device the other side of the wall.
- Wi-Fi employs signals whose wavelengths are 12.5 cm.
- Extend human vision beyond the visible electromagnetic range, allowing us to detect objects in the dark or in smoke.

9. LIMITATIONS

- Display has very low resolution.
- We cannot detect humans behind concrete walls thicker than 8.
- To achieve a narrow beam the human needs to move by about 4 wavelengths (i.e., about50 cm).

10. FUTURE ENHANCEMENT

- wivi could be built into a smartphone or a special handheld device.
- High quality images
- Evolution of seeing humans through denser building material and with a longer range.

11. CONCLUSION

We gift Wi-Fi, a wireless technology that uses Wi-Fi signals to find moving humans behind walls and in closed rooms. In distinction to previous systems, that square measure targeted for the military, Wi-Fi allows tiny low cost see- through-wall devices that operate within the philosophy band, rendering them possible to the final public.

Wi-Fi additionally establishes a channel between itself and a person's behind a wall, permitting him/her to speak directly with Wi-Fi while not carrying any sending device. we tend to believe that Wi-Fi is associate degree instance of a broader set of practicality that future wireless networks can offer. Future Wi-Fi networks can probably expand on the far side communications and deliver services like indoor localization, sensing, and

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management. Wi-Fi demonstrates a sophisticated variety of Wi-Fi-based sensing and localization by victimization Wi-Fi to trace humans behind wall, even after they don't carry a wireless device. It additionally raises problems with importance to the networking community pertinent to user privacy and laws regarding the utilization of Wi-Fi signals. Finally, Wi-Fi bridges progressive networking techniques with human-computer interaction. It motivates a replacement variety of user interfaces that swear entirely on victimization the reflections of a transmitted RF signal to spot human gestures. We tend to envision that by investing finer nulling techniques and using higher hardware, the system will evolve to seeing humans through denser artifact and with a extended vary. These enhancements can additional permit Wi-Fi to capture higher quality pictures enabling the gesture-based interface to become additional communicative hence promising new directions for computer game.

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