

Seeing Through Walls Using Wi-Vi

Munipalli UmaMaheswararao¹, Bala Brahmeswara Kadaru²

¹Assistant Professor, Computer Science and Engineering, GEC, Gudlavalleru, AP, India.

²Computer Science and Engineering, GEC, Gudlavalleru, AP, India

Abstract - Wi-Fi is a well-known innovation which enables an electronic gadget to interface with the web remotely utilizing radio waves. Wi-Fi signals are only the data bearers amongst transmitter and collector. Wireless Vision (Wi-Vi) is another innovation like a similar idea of Wi-Fi which empowers seeing through walls with the assistance of Wi-Fi signals.. This paper investigates the capability of utilizing Wi-Fi signals and late advances in MIMO(multiple input, multiple output) interchanges to construct a gadget that can catch the movement of people behind a wall and in closed rooms. Wi-Vi's operation does not require any access to any electronic device on the other side of the wall. By using Wi-Vi technology we can track moving human beings through walls as well as behind closed doors.

Keywords - Wi-Fi, MIMO, Wi-Vi, Transmitter, Technology

1. INTRODUCTION

This paper gives the thought regarding the capability of utilizing Wi Fi signals. There are new advances in MIMO communications to assemble a gadget or a system that can catch the movement of people behind a wall or closed room and in door. Law enforcement staff can utilize this gadget to abstain from strolling into a scupper and limit losses in prisoner circumstances. Crisis responders can be utilizing it to see through the fallen structures or flotsam and jetsam. The benefits of this for standard clients are the gadget for gaming, usurpation location, protection improved observing of kids, elderly or individual security when venturing into dims paths and obscure spots. The idea of this seeing through dark is like sonar and radar imaging.

Wi-Fi signals are commonly data bearer signals between a transmitter and beneficiary. Presently it is conceivable with the Wi-Fi signs can likewise broaden our senses [1]. They empower us to see moving articles through walls and behind the doors closed. So it is conceivable with the assistance of such signals to recognize the quantity of number of individuals in the room and their specific location in a closed room. We can also distinguish signals made behind a wall and join the arrangement of signals to impart messages or reports to a remote recipient without having any sort of transmitting gadget. Wi-Vi signifies "Wi-Fi" and "Vision" which is only remote vision. It's another promising innovation that empowers seeing through the walls utilizing Wi-Fi signals. It likewise enables us to track moving items or human through closed rooms and behind the walls. Wi-Vi in view of catching the impressions of its own transmitted flags off moving items behind a divider or entryway keeping in

mind the end goal to track them. Wi-Vi operation does not require any entrance to any gadget on the opposite side of the wall or door. In particular, when it is cooperate with a non-metallic wall, some type of the RF flag would navigate the wall; reflect off items and people [2]. It returns with a sign of what is inside a closed room. By catching these reflections, it is conceivable to picture questions behind a divider or entryway. Building a Gadget or framework that can catch. Such reflections are troublesome on the grounds that the signal power after entering the wall twice (all through the wall) is diminished by three to five times of magnitude [3]. Indeed, even the troublesome test is simply the reflections from the wall, which is stronger than the reflections from articles inside the room. A reflection off the wall on the receivers simple analog to digital converter i.e. ADC, keeping it from considering the small variations because of reflections from objects behind the wall [4]. This type of behavior is called as the "Flash Effect" since it is like how a mirror before a camera flashes the camera's glimmer and anticipates it from capturing objects in the scene [5].

2. RELATED WORK

Wivi is mainly related to major three areas

A.Through Wall Radar

B.Gesture based interfaces

C.Infrared and Thermal Imaging

A. Through wall Radar:

Seeing through wall has been observing for about a decade. In olden days inventors have been mainly focusing only on the modeling and Simulations. At Present time we are having few implementations that have been tested while human are moving. In past design of the systems and the devices have removed the flash effect by isolating the reflected signal of the wall from the reflected signals of the objects that are behind the wall. The process of the Isolation can be achieved by the time domain with the help of very short pulses (less than 1ns) due to this we have developed based up on the arrival time of the reflected signal of the wall and also the reflected signal of the moving objects that are behind the wall. The process of the Isolation can also be achieved based up on the frequency domain through the linear frequency signal given by L. Kempel, E. Rothwell, C. Coleman, G. Charvat and E. Mokole et al in 2010. In this process the reflections of objects at a variant distances come with variant tones. By performing the analog filtering to the tone which

corresponds to the wall and it leads to remove the flash effects. To perform all the techniques we require the Ultra-Wide bands (UWB) of the order of 2GHz.

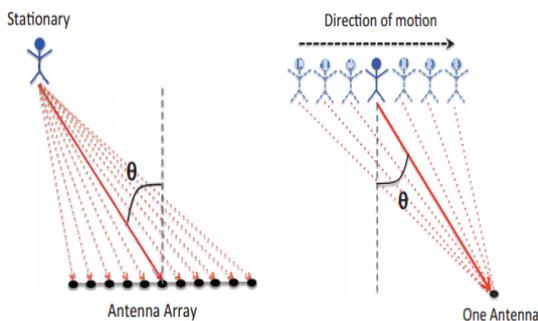
Wi-Vi Technology is totally different from the above systems. In the Wi-Vi Technology, it will be requiring only the MHz of Bandwidth and performs operations in the same range wifi. This removes the flash effect by using the MIMO nulling concept so it does not require the UWB. Researchers have originates limitations for the UWB systems and also derived the narrowband radars through wall which occurs by moving objects behind the wall and the closed door. Wivi gives a new method for eliminating the flash effect without wideband transmission. So this method will be working on the concrete walls, Solid wood doors and also in the fully closed rooms. The Process of seeing through walls was implemented in the year 2012. In this particular system it needs both the transmitter and the reference receiver in the room has to be connected to the same clock as the receiver outside the room. But in Wi-Vi we can perform through wall imaging without access to any device on the other side of the wall.

B. Gesture-based interfaces:

Now days commercial gesture recognition systems such as the Nintendo Wii, Xbox Kinect, etc, can identify a wide variety of gestures. The researchers have also developed some systems which are capable of identifying human gestures either by using cameras or by placing the sensors on the human body. Recently the narrow band signals strength has also been improved to 2.4 GHz to observe the human activities in line-of-sight using Micro-Doppler signatures. Wi-Vi Technology presenting that the first gesture based interface has worked in non-line-of-sight scenarios, and also through a wall. This particular technology does not require the human beings to carry any device or carry any type of sensors.

C. Infrared and Thermal Imaging :

Similar to the Wi-Vi, these technologies also develop the human vision beyond up to the visible electromagnetic range. It will also allow the user for observe or to detect the objects in the smoke or in the dark.



(a) Antenna Array (b) ISAR
Fig. 1. Antenna Arrays and ISAR

In this process they can operate by capturing the infrared and thermal energy reflected from the first obstacle or object in the line-of-sight of their particular sensors.

Despite of this the cameras based up on such type of these technologies can't see through the walls or closed doors because they are having very short type of wavelengths in few μm to sub-mm, where as Wi-Vi having wavelengths upto 12.5cm^3 . In the given figure (a), an antenna array will be able to locate the object by steering its beam spatially. In figure (b) the moving object itself will be emulating an antenna array, So from this we can say that it acts as an inverse synthetic aperture.

3. WI-VI OVERVIEW

Wireless vision is a device which operates wirelessly and captures the moving objects behind the wall and the closed door. It will be using the WiFi OFDM signals from the ISM band and the Wi-Fi hardware. This wireless device is basically a 3 antenna MIMO device where the two antennas help in transmission while the other helps in reception. While the other directional antennas used helps in focusing the energy towards the wall. It also having different advantages such as it can make wall imaging relatively low cost, low power and low-bandwidth which is accessible to all the users.

The design of the Wi-Vi having mainly two components:

- 1) The first components can be used for eliminating the flash reflected of by the wall by using the MIMO nulling process.
- 2) The second component can be used for the purpose of tracking the moving object by considering the object as an antenna array using the technique called Inverse SAR i.e. ISAR. The Wi-Vi Technology can be used in the above two modes.

Table 1: One-Way RF Attenuation in Common Building Materials at 2.4GHz

Building Materials	2.4 GHz
Glass	3dB
Solid wood Door 1.75 inches	6dB
Interior Hollow Wall 6 inches	9 dB
Concrete Wall 18 inches	18dB
Reinforced concrete	40 dB

In mode 1, it can be used as the image moving objects behind the wall or closed door; it is possible for tracking the objects. In mode 2, WiVi can be used as a gesture-based interface from behind the wall which enables humans to create the messages and sending to the Wi-Vi receiver.

4. ELIMINATING THE FLASH

In every wall system, the signal reflected from the wall is the flash, which is stronger than the any other signal reflected from the objects from behind the wall. This is due to the weakness of the electromagnetic signals suffers while going through the dense obstacles. For example – if the signal has traversed through the solid wood door or to the interior hard wall, then the Wi-Fi signal power will be reduced up to 9db and 18db respectively. Hence, Wi-Vi increases the susceptibility for the reflection of the interest by deception the improvement of the nulling or by power boosting.

5. IDENTIFYING AND TRACKING HUMANS

5.1 Tracking A Single Human

In now-a-days the wall systems are tracking the human motion by using the antenna array. They are moving the arrays beam to the specified direction where the maximum energy exists. The direction will be approaching to the signal's spatial angle of arrival. By tracking that particular angle in time, they speculate how the object is moving in the space.

Wi-Vi will avoiding the antenna array mainly for two reasons: Firstly in order to retrieve a narrow beam and will be achieving a good resolution, one needs a large antenna array with many antenna elements, which results more expensive devices. Second, the Wi-Vi eradicate the flash effect by using the MIMO nulling which adds multiple receive antennas which require the nulling signal at each of them. This is used for adding more transmit antennas and making the device even massive and more extravagant.

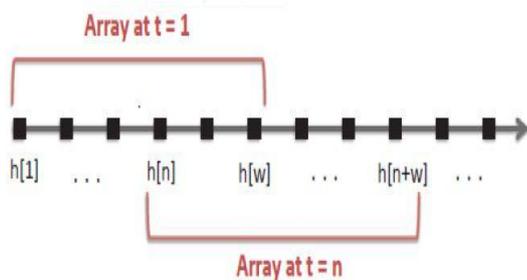


Fig. 2. Time samples as Antenna Arrays

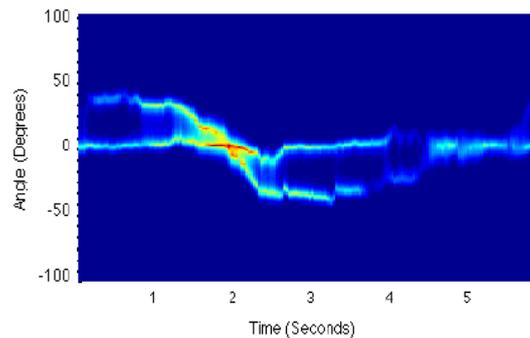


Fig. 3. Wi-Vi tracks a single person's motion

5.2 TRACKING MULTIPLE HUMANS

In this particular section we will be showing how the Wi-Vi extends its tracking technique to multiple humans. Each human will be emulating a separate antenna array. Since Wi-Vi is having a single antenna, the receiving signal will be a superposition of the antenna arrays of the moving humans in the location. the multiple humans the noise will be increasing automatically. Also, human is not just one object, since it has different body parts. The signal that reflects from all of the humans is correlated in time, since they reflect the transmitted signal. Sometimes, the presence of multiple humans can cause problems where the reflections combine which dim each other over some period of time.

6. THROUGH WALL GESTURE-BASED COMMUNICATION

As a human being for transmitting a message to a computer wirelessly, consistently He/ She must carry a wireless device. In this the Wi-Vi can enable the human who will not carry any wireless device for communication. Wi-Vi will be representing these gestures "0" bit and "1" bit. Later we can compose these gestures for creating the messages which are having different interpretations. Additionally the Wi-Vi will be evolving by borrowing other existing principles such as adding an easy code which is having the reliability or we can also reserve the '0's and '1's for the packet preambles.

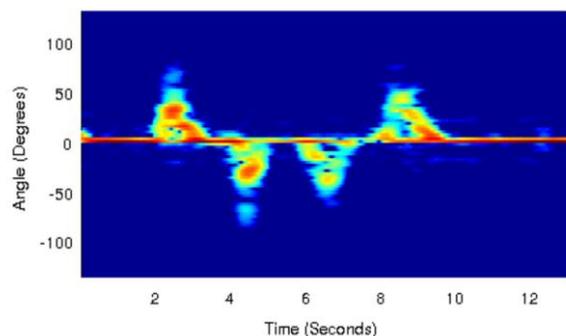


Fig 4: Gestures as detected by Wi-Vi

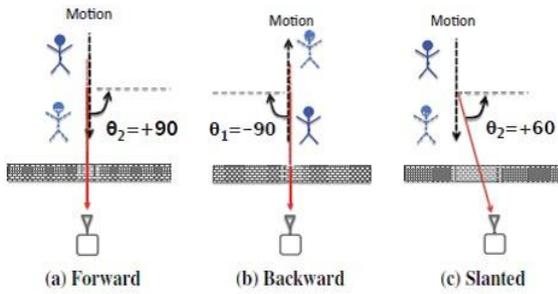


Fig 5: Gestures as Angles

Gesture Encoding

At transmitter, 0 and 1 bits are encoded using a modulation scheme. Wi-Vi implements this encoding using the gestures. A wide range of gestures can be used to represent the bits

Conditions for Gesture Encoding:

- The human must be in the initial state itself as at the start of the gesture.
- Gesture must be simple.
- It must be easy to detect and decode.

0 bit indicates: a step forward by a step backward.

1 bit indicates: a step backward by a step forward.

The spatial angle connecting between human to the Wi-Vi device will be positive when the human moves toward the Wi-Vi and it will be negative when the human moves away from the Wi-Vi.

Gesture Decoding

Gesture decoding is simple and it uses the techniques of standard communication. The Wi-Vi takes the input. Wi-Fi applies two matched filters one for the step backward and other for the step forward. Wi-Vi applies the matched filter to the received signal and adds up to get the output.

7. CONCLUSION

We exhibit Wi-Vi, which is a wireless technology which uses the Wi-Fi signals for recognizing the moving objects and humans behind the walls and closed doors. Compared to the previous systems the Wi-Vi technology enables the small and cheaper devices for seeing through the walls which are operated in ISM band. It also provides the communication between the human in the closed door and itself allowing him/her to communicate directly without using any transmitting device. Further the Wi-Fi networks are to be expanded to services such as indoor localization, sensing and control.

8. REFERENCES

- [1] Sudarshan Adeppa, "Detection of Objects across the Walls with Wi-Fi Technology", International Journal on Emerging Technologies, 2015.
- [2] K. Chetty, G. Smith, and K. Woodbridge, "Through-the-wall sensing of personnel using passive bistatic wifi radar at standoff distances," IEEE Trans. Geoscience and Remote Sensing, 2012.
- [3] Adib, Fadel, and Dina Katabi, "See through Walls with WiFi," Proceedings of the ACM SIGCOMM Conference, 2013.
- [4] S. Ram and H. Ling, "through-wall tracking of human movers using joint doppler and array processing," IEEE Geoscience and Remote Sensing Letters, 2008.
- [5] Prerna Garg, Shikha, "Wi-Vi Technology", International Journal of Advance Research In Science And Engineering, Vol. No.2, Issue No.9, September 2013