

Tracking human motion using: WI-VI

¹Ankita Shrivastava, ²Ravi Shankar

^{1,2}Department of IT, C. V. Raman College of Engineering, Bhubaneswar
ankitashrivastava410@gmail.com¹, rs007dayal@gmail.com²

Abstract—This paper introduces the technology of WI-VI, a technology that allows us to see through the walls with the use of Wi-Fi signals. In other words, it helps us to detect human motion through the walls and behind the closed doors. This technique has been quite in use in the military area and recent advances in this technology have opened doors to its application in other areas as well. In this paper, we will go on discussing what this technology is, how a device using this technology is made, challenges faced in making such a device, methods to overcome it and its applications in different fields.

Index Terms— Seeing through Walls using Wi-Vi, MIMO, Flash Effect, ISAR

I. INTRODUCTION

The only use of Wi-Fi signals we know these days is to connect to the network of other mobile or laptop so that we can use the internet but, who could imagine that these signals could be used to detect human motion from behind the closed doors just like a superhero power of X-ray vision like that in a marvel movie. This technology of Wi-Vi has been hitting the market very recently and has been a topic of discussion and research for every IT professional in every IT field.

The concept underlying this technology is same as the concept of sonar and radar. To be specific here, when a RF signal comes in contact with a concrete type of wall, then some parts of the Radio Frequency signal will pass through that wall, will reflect off the things as well as human beings, then comebacks punched with the impression of things that are present behind the wall. So, if we can capture these reflections then we can easily predict what objects are present in the room.

However, making such device will be difficult because of the problem of flash effect that will be discussed later in this paper and we will also throw some lights as to why WI-FI signals were preferred over RF and the methods to overcome the difficulties. This technology can be applied in many areas such as medical field and what not.

II. CONSTRUCTING A WI-VI DEVICE

A device implementing Wi-Vi technology is constructed with two transmitting antennas and one receiving antenna. A Wi-Vi device performs its operation in two stages.

III. DIFFICULTIES IN MAKING A DEVICE AND METHODS TO OVERCOME THEM

As discussed earlier in this paper that a device that could capture the reflection behind the closed door is difficult to construct because of the number of problems which we will be discussing now in details and also the methods to overcome them:

A. Flash Effect

When the RF signals passes through the wall, hits the objects behind the wall and comes back and then passes the wall all over again, its magnitude is diminished by three to five. Even more problematic are the reflections of the wall that the RF signals passes through, which are more powerful in comparison to the reflections of the things placed inside the room. These reflection that come from the wall overpowers the signals of the objects inside behind the closed door and thus the ADC or analog to digital converter of the receiver, thereby stopping it to capture the variations caused by the reflections from the things residing behind the wall. This behavior is called the "Flash Effect".

So how can we surpass this difficulty of flash effect? The answer was provided by the radar community that came up with some system which could easily detect human being's motion at the back of the wall, and represent them as blobs moving around in a black and white background. The present day's ultra-modern system needs a very large power source, 2GHz of bandwidth and an antenna array which is almost 8 foot long. In addition to all the requirements that the device requires, it is not possible on such a large scale for normal people except for the military. The need of multi-GHz transmission is the core of how the device will work: it will differentiate between the reflections from the wall and the reflections of the objects present inside the wall based on their arrival time and thus separating them, and so the device needs to note

even the smallest delay in arrival time to overcome the flash effect

And so because of all the limitations stated above, the use of Wi-Fi signals was proposed in the year 2012 that could overcome the problem of flash effect without needing GHz of bandwidth with the help of technology called MIMO communication. In this technology, there are a number of antenna systems that will encode the transmissions making the signal nullified at one of the receiving antenna. MIMO systems use this ability to overpower the interferences to receivers that are not required. In contradiction to, we are using the concept of nulling the signal to kill the reflections that come from the nonmoving objects i.e. the wall. Coming to the construction of the Wi-Vi device, a Wi-Vi device has transmitting antennas that are two in number and one receiving antenna. The Wi-Vi devices have two stages of operation. In stage one, it takes the measurement of the channels from each of its transmitting antennas to its receiving antenna. In the second stage, the transmitting antenna uses these measurements of first stage to nullify the signal at the side of the receiving antenna. As these signals that are wireless (including reflections) combine with each other linearly over the medium, reflection from the things moving between the stages are captured here in the second stage and this how the reflections from nonmoving objects, and the wall itself, are nullified in the first stage. Then refining is done by introduction of repetitive nulling, which enables us to remove the leftover flash effect and all the low magnitude reflection from nonmoving objects in the closed room.

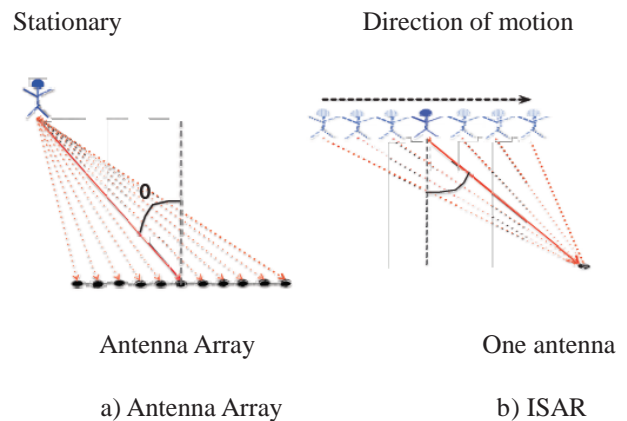
B. Tracking of moving objects without an antenna array

To overcome this problem, a technique of ISAR known as inverse synthetic aperture radar is used. ISAR used to generate two dimensional image of the object. As far as its use in the outer space is concerned; it is used to map the surface of the planets. This technique with the help of the human movement generates an array of antenna. Figure 1 here depicts the concept of the above statement, a device that will use antenna array to catch the object from specially kept antennas and processes the information to know the target's direction respect to the array. In opposition to what we discussed earlier, in the ISAR way, only one receiving antenna is there and so at any time, one can capture a slightest single measurement. But then, as the object of interest is in the moving state, there will be continuous movement and so an inverse like antenna is produced by consecutive measurements in time. By processing such consecutive measurements with the help of beam string, the technology of Wi-Vi will help us to identify the special direction and motion of the respective humans behind the wall.

Along with that, the technology of Wi-Vi balances its capability to track human motion enabling a see through the wall gesture based communication channel.

Specifically speaking, a human will be able to communicate his or her message to the Wi-Vi device receiver using signs without the use of any device that is wireless. Let's take an example- lets pick two body movements or gestures and refer it as "0" and "1" bits. So using these gestures, a human can communicate a message to the device.

After the application of a matched filter, the message signal very much looks similar to a standard BPSK encoding (a positive signal for a "1" bit, and a negative signal for a "0" bit) and thus could be easily decoded by considering the signs of the signals. This technique allows law enforcement officer to have a communication with his group or team members on the other side of the wall, even if their other communicating devices have stopped working.



IV. APPLICATIONS OF WI-VI

In recent years, numerous applications of Wi-Vi have come up besides the military application. Applications of Wi-Vi are as follows:

A. Detecting heart rates and Human motion through the Walls at our house:

By using the technology of Wi-Vi, we can detect the heart beat and other vital signs like respiratory charge of a human being while he or she is sleeping. This is very very beneficial as these things can help us know the health and fitness of that individual. Not only this, it can also be quite helpful in knowing or detecting if he or she is suffering from any kind of disease like anything related to sleep, lungs or even heart. This is possible by determining respiratory charge, that can help us know our heart condition and that way we can locate many diseases. This wonderful thing can be achieved using the wi-vi technology along with the help of vital radio which is very important as it is quite helpful in detecting the health and fitness of that person and thus will provide all the medical detail of that person which will be quite helpful in coming to a conclusion about his health. We can detect diseases like chronic pulmonary disease and sleep apnea by

determining the respiratory charge and thus the heart rate of that individual.

B. Disaster Management and Military Based Help using Drones:

One of the best applications of Wi-Vi is the drones for surveillance which could be used for detecting human movements easily and saving lives of the civilians in times like disaster and war. For example-If a building is collapsed due to earthquake and there are people stuck inside it, then using these drones we can see their slightest gestures and help in rescuing them and saving their lives. Not only this, these drones can be used during wars to detect the activities of enemies and thus plan a strategy to attack.

The drone is made using Quad-Copter consisting of Wi-vi sensor ,a camera that is infrared in nature and a GPS tracker to track motion from a distance that are far off and not accessible easily.

V. ADVANTAGES AND LIMITATIONS OF WI-VI

A. ADVANTAGES:

- The technology of Wi-Vi is comparatively less power consuming, less costing and it requires low bandwidth.
- It needs less Megahertz of bandwidth and performs its operation in the very same range as that of Wi-Fi.
- It can help us to have an imaging of objects placed behind the wall without needing any wireless device behind the wall.

B. LIMITATIONS:

- The display does not have a high resolution.
- Human beings behind any concrete wall thicker than 8 inches cannot be detected.

VI. CONCLUSIONS

In this paper we discussed the wireless technology of Wi-Vi which using the concept of Wi-Fi signals can help us in detecting moving human beings behind the closed doors or places that are far off. In opposition to the old system of detection that were only used by the military people , Wi-Vi allows us to build a small cost effective device to see through the walls using Wi-Fi signals without requiring the person behind the wall to carry any device. This technology can be used not only during disasters to detect people trapped behind tons of concrete but also in the medical field to detect the symptoms and thus disease.

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