Detection of Indoor Objects Using Radar Based Wi-Vi

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Abstract : Wi-Fi is one of from the technologies which allow us to make connection between electronic gadgets and web remotely utilizing radio waves. Using this technology, there is new innovation of Wi-Vi technology which uses reflected Wi-Fi signal track moving human being through wall and closed door also. Wi-Vi is not needed to access electronic device on other side of wall.

      This paper explores the benefits of Wi-Vi of exploiting Wi-Fi signal and recent advance in MIMO (Multiple Input Multiple Output) communications building a device that can track moving object as well as human behind the wall. Wi-Vi is established on the principle of RADAR and SONAR. RADAR is a system which detect object using radio wave to determine the range, altitude, direction and speed of objects. Current radar-based systems used in U.S. Military are so huge they need to be transported on trucks. Even Army also needed a portable tool for seeing through wall in certain setting. Wi-Vi's facility also helps for searching the people which are trapped in collapsed earthquakes, because of its low resolution Wi-Vi could actually lift people's privacy rather than spoil it in some cases.

Keywords: Wi-Fi, Wi-Vi, SONAR, RADAR, MIMO, Indoor objects.

I. INTRODUCTION

      This paper introduces a new innovative technology Wi-Vi which is promoting Wi-Fi signal. MIMO is a radio communication technology or RF technology which is used in many technologies and a new approach in MIMO communication is to accumulate a system that can detect the indoor objects.

      Exchanging of information between two or more devices is possible due to Wi-Fi technology which is developed for mobile computing devices, such as laptops but it is now greatly mobile applications and consumer electronics like television, DVD players, digital camera. Wi-Fi grants Local Area Networks to accomplish without cable and wiring, which is widely used by business networks, colleges and home. A computer's wireless adapter transfer data into radio signal and transfer data into antenna for user.

      The aid of Wi-Vi technology for applicants are gadget for gaming, appropriation location, protection improved observing of kids, elderly or individual security when undertaking into dark path and hidden spots. Wi-Vi technology also shows the potential of searching the peoples trapped in collapsed buildings after earthquakes. It could also use by police for determining the number of peoples in a room and room and their movements, blocking an ambush when they raided the room.

      Wi-Vi system uses Wi-Fi signal to detect moving object behind the wall. It is similar to RADAR and SONAR imaging. Wi-Vi operation is not needed to access the device on other side of wall, particularly when it interacts with non-metallic wall, some form of RF signal transfer the wall reflect off entities and humans and it gives answer that what is inside a closed room. Reflection from the wall itself is challenging than reflection from object inside the room. A reflection off the wall on the receiver's simple analogue to digital converter i.e. ADC, which restricted the minute variations coming through object behind the wall. This nature of an object is called "Flash Effect", since it is similar to how camera's flash is reflected by mirror in front of camera and prohibit it from capturing object in the scene. The purpose of this paper is to enable to detect indoor objects technology that is low-bandwidth, low-power, compact, and accessible to non-military entities. To this end, the paper introduces Wi-Vi, detect indoor object device that employs Wi-Fi signals in the 2.4 GHz ISM band. Limit of Wi-Vi is 20 MHz-wide Wi-Fi channel, and avoids ultra wide band solutions used today to address the flash effect. It also sets of the large antenna array instead of smaller 3- antenna MIMO radio.

II. RELATED WORK

2.1 Through-wall Radar:

Work is done on seeing through wall observing for about decade. Modelling and simulation were mainly focused by inventors. At the recent time the few implementations tested with moving human. In early work on design of work on design of the devices and system the flash effect is eliminated by doing isolation of reflected signal off the wall from reflected signal of the objects which are behind the wall. Wi-Vi system is determined on RADAR & SONAR.

To achieved isolation, the time domain is used with the help of very shout pulse. Due to this there is occurrence of delay between arrival time of reflected signal off the wall and reflected signal off the moving objects which are behind wall. Also using frequency domain through linear frequency signal the achievement of isolation can be done. Reflection from objects at variants distances arrives with variants tones in this process. The flash effects are eliminated by performing analog filtering to the tone corresponding to the wall.

The ultra-wide bands are needed to order 2GHz is needed to perform all these technologies. RADAR principles which are applicable for military purpose also need UWB. Wi-Vi is RADAR based technology requires only MHz of bandwidth and same range Wi-Fi performs operations. Wi-Vi using MIMO nulling to eliminate flash effect and avoid the requirement of UWB systems for which limitation are found by researchers. Researchers also derived the narrowband radius through wall is occurs by movement of objects behind the wall and the closed doors. Due to this method the work with concrete wall and solid wood doors as well as fully closed rooms is done due to elimination of flash effect with wideband transmission. Wi-Vi enables us to perform through wall imaging without accessing any device on the other side of the wall.

2.2 Gesture Based Interface

To identify verity of gesture now days, the commercial gesture recognition systems such as the Nintendo Wii, Xbox Kinect, are used. Also there are some systems which can identify human gesture by operating cameras or placing sensor on the human body advanced by researchers. Newly the narrow band signals strength of range 2.4GHz for observation of human activities in line of sight using Macro-Doppler signature. Wi-Vi, however presents the first gesture based interface that works in non-line of sight scenarios as well as through the wall. Due to this specific technology human is not require to carry any wireless device or wear a sensor on their body.

2.3 Infrared and Thermal Imaging

This process can conduct by trapping infrared or thermal energy mirrored from the first obstacles or object in line of sight of their particular sensors. The system which is based on infrared and thermal imaging is used to extend the human vision beyond the visible electromagnetic range and also permitting human being to detect objects in presence of smoke and darkness. But using this technique we cannot see through wall because it has short wavelength (few um to sub mm), whereas Wi-Vi system having wavelength in range of 12.5um.
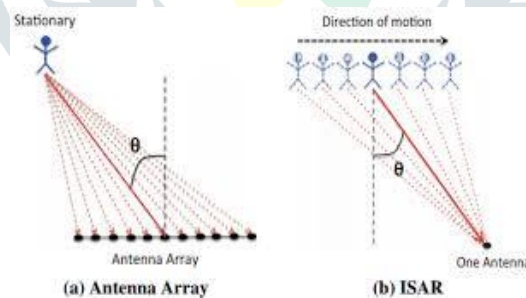

Figure 1: A Moving Object as an Antenna Array. In (a), an antenna array is able to locate an object by steering its beam spatially. In (b), the moving object itself emulates an antenna array; hence, it acts as an inverse synthetic aperture

III. ELIMINATING THE FLASH EFFECT

Electromagnetic signals which are reflected from the wall the flash, which is stronger than the any other signal reflected from the objects from behind the wall. It happens because of weakness of electromagnetic signal suffers while going through the dense obstacles. For example- If the signal has travelled through the solid wood door or to the interior hard wall, the Wi-Fi signal power will be decreased up to 9db and 18db. Hence susceptibility for reflection of the nulling or by power boosting increased by Wi-Vi.

3.1 Nulling to Remove Flash Effect

Use of antenna avoided for two reasons: First, for achieving a good resolution by obtaining a narrow beam, one needs a large antenna array with many antenna elements. Due to this the device would be bulky and expensive. Second, by using MIMO

nulling Wi-Vi eliminates the flash of effect, nulling the signal at each of them require by adding multiple receive antenna. Hence, there is need of more transmit antenna thereby permitting the Wi-Vi to capture from object of interest with minimal interface.

Wi-Vi's procedure for elimination of flash effect:
•For elimination of flash effect, we have to remove reflected signal that are received from stationary objects both in front of and behind the wall and direct signals from transmitting antenna to receiving antenna.
•Wi-Vi's uses nulling algorithm which provides a 42dB mean reduction in signal power that helps to remove flash effect.
•In presence of objects moving behind the wall and in front of wall, nulling can be performed
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IV. IDENTIFYING AND TRACKING HUMANS

4.1 Tracking a Single Human

In recent wall system are tracking the human motion with the help of antenna array. They are moving the array beam to determine the direction of maximum energy and this direction corresponds to the signal's spatial angle of arrival. By tracking that angle in time we can speculate the movement of object in the space. Wi-Vi avoiding the use of antenna array mainly for two reasons: First, in order to acquire a narrow beam that means to achieve a good resolution one needs a large antenna array with many antenna elements, which would results to a bulky and costly device. Second, since Wi-Vi eliminating flash effect with the help of MIMO nulling, addition of multiple receive antennas would require nulling the signal at each of them. This requires adding more transmit antenna which makes the devices bulkier and more expensive.
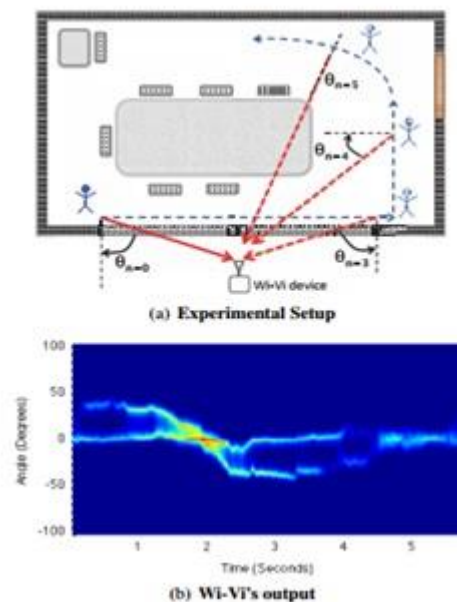

Figure 2: Wi-Vi tracks a single person's motion. (a) shows how Wi-Vi is able to track the motion of the person by computing the variation of the inverse angle of arrival with time, i.e. A![θ, n] for θ in [−90◦, 90◦]. (b) shows the experi-mental setup of a trial which consisted of a single person moving around in a conference room.

4.2 Tracking Multiple Humans

In this section Wi-Vi extending its tracking technology from single human to multiple humans. As in our previous section   we consider human motion as antenna array, therefor in multiple tracking each human will be emulating a separate antenna array. Since Wi-Vi has a single antenna, so the received signal will be in superposition of antenna array of the multiple moving humans in the location. Now this time, there will be number of curved lines instead of one curved line as moving humans at that point in time.

However, with multiple human, the noise increases automatically. Also human is not just an object, it has different body parts which are moving in a loosely coupled way. As signal reflected from human are transmitted signal, they are correlated in time. The lack of independence between reflected signals is important. Sometimes the presence of multiple human results in problem as the reflection of two humans may combine systematically which dim each other over some period of time.

4.3 Through Wall Based Gesture and Communication

Wi-Vi can allow human who does not carry any wireless device can communicate to receiver with simple gesture. Wi-Vi representing these gestures "0" bit and "1" bit. Later human composing these gestures for creating the messages which are having different interpretations. Additionally, the Wi-Vi can develop with the help of other existing principle such as adding a simple code that can ensure reliability or we can also reserve the '0's and '1' for the packet preambles. This technology is still very basis, yet we trust that future advancement will make it more reliable, expensive.
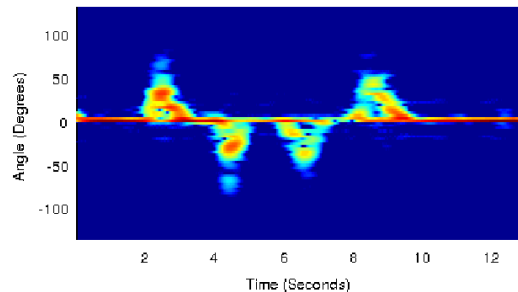

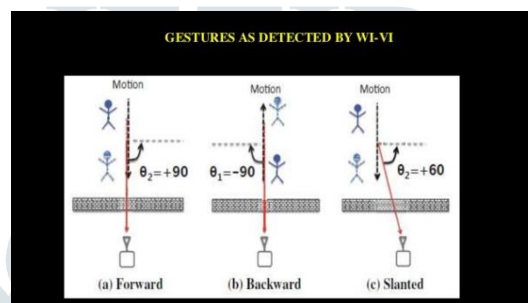**Figure 3: Gestures as detected by Wi-Vi**

Figure 4: Gestures as Angles

4.4 Application

Emergency responders can use Wi-Vi see through rubble and faint structure. This invents the technology which could use for searching in rescue operation and disaster area.

4.5 Advantages

Wi-Vi operates in the same range as Wi-Fi and operates in ISM band. Wi-Vi requires only few MHz of bandwidth. It also extends human vision beyond the visible electromagnetic range, allowing humans to detect indoor objects.

4.6 Disadvantages

It has low range of resolution device. We can detect the human behind the wall which is thicker up to Eight inches (8Inch).

V. CONCLUSION

If Wi-Vi technology can be put into practical use, it can be used in many applications such as recognition of moving objects behind the wall and more improvements can make this technology more accurate and better. Wi-Vi technology enables the small and cheaper devices for seeing through the walls which are controlled by ISM band. Communication between the human in the closed door and itself allowing him/her to communicate directly without using any transmitting devise is possible due to only this technology. Further the Wi-Fi networks are to be expanded beyond communication and deliver services such as indoor localization, sensing and control. By using this technology in future we would be able to detection of indoor objects by using smartphones.

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