**RADIANT BODY MESH USING WIFI CSI**

**ABSTRACT:**

Traditional methods for figuring out human body position (pose estimation) using cameras and special sensors have limitations. Cameras don't work well in shadows or with overlapping objects, and the special sensors are expensive, bulky, and might raise privacy concerns. This research proposes a new method that uses existing Wi-Fi signals to estimate body pose. By analysing the strength and direction of Wi-Fi penetrating through human regions (i.e. Dampening of signals), the system can create a heat map showing distorted body position, on which DensePose model is applied to predict the exact structure and position of a human figure. This approach is low-cost, can work through walls, and protects privacy since it doesn't rely on cameras or needing people to wear sensors. Tests show this Wi-Fi based method is accurate and paves the way for new applications in human sensing.

**INTRODUCTION:**

Researchers have made big strides in figuring out human body position (pose estimation) using different sensors like cameras (RGB sensors), LiDARs, and radars. These sensors are useful in things like self-driving cars and augmented reality. However, they have limitations. LiDAR and radar sensors are expensive (think $200-$700) and use a lot of power, making them impractical for everyday use. Cameras can't see well in the dark or when there's glare, and furniture or other objects can block the view of the person. Most importantly, using cameras in private places like bathrooms raises privacy concerns. These limitations are especially a problem for healthcare at home, where elderly people might be monitored with these sensors. New solutions are needed to help seniors live independently, especially during situations like COVID. Our proposed model can also be used (with further development) to tackle hostage situations where direct vision is difficult to obtain. This is because our model relies purely on WiFi signals and has a high accuracy compared to other models.

It is already researched that WiFi signals can serve as a ubiquitous substitute for RGB images for human sensing in certain instances. Illumination and occlusion have little effect on WiFi-based solutions used for interior monitoring. In addition, they protect individuals’ privacy and the required equipment can be bought at a reasonable price. In fact, most households in developed countries already have WiFi at home, and this technology may be scaled to monitor the well-being of elder people or just identify suspicious behaviours at home.

WiFi-based perception is based on the **Channel-state-information (CSI)**

that represents the ratio between the transmitted signal wave and the received signal wave. The CSIs are complex decimal sequences that do not have spatial correspondence to spatial locations, such as the image pixels. Secondly, classic techniques rely on accurate

measurement of time-of-fly and angle-of-arrival of the signal between the transmitter and receiver. These techniques only locate the object’s centre; moreover, the localization accuracy is only around 0.5 meters due to the random phase shift allowed by the IEEE 802.11n/ac WiFi communication standard and potential interference with electronic devices under similar frequency range such as microwave oven and cell phones.

These factors were already researched upon and a architecture has already been created to address these issues. Taking inspiration form the already proposed architectures on WiFi sensing DensePose models, we intend to further increase the accuracy and preciseness of the models by adding WiFi based heat mapping. Our architecture includes sensing the dampened WiFi signals through a human body and then applying the DensePose architecture on it to predict the position and pose of the human regions.

**LITERATURE SURVEY:**

Work on dense estimation from pictures and human sensing via WiFi is briefly described in this part. In computer vision, the subject of dense pose estimation from pictures and videos has received a lot of attention[1,2]. Lin et al., 2021 directly regresses mesh vertex coordinates using the Transformer model via hundreds of vertex queries[3]. While many researches have been done on detection, tracking and dense pose estimation from images and videos using CNNs , human pose detection from Wi-Fi and radars are a rather unexplored topic. The pioneering work RF-Capture (Adib et al., 2015) demonstrated the possibility of capturing human figures through walls using radio frequency (RF) signals, which has since attracted attention in the field of human pose and shape estimation[4,5]. The first work regarding the use of Wi-Fi signals for the detection of humans subjects we could find is the work of Chetty, Smith, and Woodbridge in 2012 [6]. Their work utilized passive Wi-Fi signals propagating through a building with receivers placed outside the building for presence detection. In 2013, a different group published a paper showing how to use signals in the 2.4 GHz range, i.e., compatible with Wi-Fi transceivers, for simple gesture detection using Doppler shift analysis[7]. The first work discussing the use of CSI for gesture recognition was published in 2015 [8]. This work looks into the use of CSI and outlier detection to detect gestures, achieving 92% gesture recognition accuracy on four gestures in a line-of-sight experiment and 88% accuracy in a non-line-of-sight experiment. Wang et al. in 2019 proposes the use of an array of three transmitter and three receiver antennas to directly predict body segmentation and pose estimation of persons located in between the aforementioned antennas [9]. In this 8 Domain Agnostic Wi-Fi CSI Gesture Classification work, they used an RGB camera to provide ground truth annotations. Using the same dataset, Geng, Huang, and De La Torre published DensePose in 2022 performs similarly, but instead produces UV coordinates of the subjects[10].

**OBJECTIVES:**

* To be able to keep track of human movements at the time of occlusions and low visibility.
* Increased privacy in hospitals and nursing homes without the use of cameras monitoring the patients.

**TECHNOLOGIES USED:**

Technologies used in this project are Wi-Fi CSI ,DensePose-COCO(Meta’s ML model for game development), hardware components related to a router and transmitters, Computer vision , Deep learning libraries.

**METHODOLOGY:**

DATA COLLECTION USING WIFI CSI

Collect WiFi CSI data using compatible hardware (such as WiFi routers or dedicated CSI collection devices) in an environment where human activities are being performed via WiFi damping. Use the heatmap visualization tool/library to plot the WiFi signal strength or metric values as a heatmap overlaying the spatial map of the target area.

DATA PRE-PROCESSING

Pre-process WiFi CSI data to extract relevant features or transform it into a format suitable for fusion with visual data using techniques such as time-domain analysis, feature extraction, or dimensionality reduction, normalization.

FUSION AND MODEL DEPLOYMENT

We will be developing a fusion layer or network that can take leverage both the information effectively . Designing a neural network architecture (e.g., RCNNs, transformers and a custom architecture like Stable Diffusion that takes synchronized DensePose images and corresponding CSI data as input to predict DensePose surface coordinates.

DENSEPOSE ARCHITECTURE

Obtain a pre-trained DensePose model or train your own using relevant datasets and frameworks like PyTorch. Convert the 2D RGB heatmaps image pixels to 3D surface coordinates of the human body. This process typically involves several steps, including DensePose inference, mesh generation, and possibly additional post-processing for refinement.

TRAIN, EVALUATE , OPTIMIZE

Train the DensePose + CSI fusion model using the compiled dataset and appropriate loss functions to maximize the output of the model. Fine-tune the model’s architecture and hyperparameters based on the training and testing results.

Optimize the model for real-time or near-real-time performance for deployment in practical scenarios.

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