Thermopile Infrared Sensor based Posture Recognition in Randomly Deployed Positions

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I. Motivation

Researchers have implemented many posture recognition systems using cameras. However, they are not well accepted by the users for real-life long-term applications. The main reason is that the camera based systems are privacy invasive for long-term applications. We developed a device-free, non-privacy invasive indoor human posture recognition system using low-resolution infrared sensors. The system uses thermopile infrared sensors to recognize postures. Our system has already demonstrated high recognition accuracy. Meanwhile, there are several challenges to deploy the system in real-world scenarios.

Fig. 1 (Left) IR sensor based posture recognition system. (Right) IR image of a person standing with arms open.

Although existing IR-based posture recognition systems achieve high accuracy, it is difficult to deploy the system in a real-world application. The reason is about the deployed positions of IR sensors. In the existing solutions, the location of deployed IR sensors must be kept the same in both training and testing stages. In addition, to achieve better accuracy, the position of the IR sensors must be carefully selected and calibrated. However, in a real-world application, the users cannot make measurements and calibrations before installing the IR devices. Moreover, for different applications, the positions of deployed IR sensors vary. Therefore, we need a posture recognition solution which allows users deploy the IR sensors at any positions.

II. Research Requirements

The number of IR sensor deployment (in various angles and distance) is huge. It is impossible to set up the system and train the machine learning model in all these kind of scenarios. In this project, we build a simulation environment to train the machine learning model. At the same time, although the simulation system can be used to produce IR image of various angles and distances, the state space of all the positions of multiple IR sensors is unlimited. We do not have enough computing resources to train a model in all possible deployments. In this project, we need to find a solution to train the model in a small number of scenarios, while the trained model could cope with the randomly deployed IR sensors.
III. Tasks

This project includes two components, including IR posture simulator and training model.

Component 1: To finish the IR posture simulator, the student must at least finish the following work steps.

1. Set up IR posture recognition hardware system. Capture IR images of various postures, distances, and angles.
2. Use a neural network model to imitate these posture data.
3. Capture IR images of various environments, such as offices, corridor, bedroom.
4. Use a neural network model to imitate these background temperature data of various environments.
5. Merge produced posture and background data. This synthetic data will be used to train posture recognition model.

Component 2: To finish the training model of posture recognition, the student must at least finish the following work.

- Although we have a simulation system (as in component 1) to produce IR image of various angles and distances, the state space of the position of multiple IR sensors is unlimited. For example, we deploy 3 IR sensors, and suppose the sensors are deployed with the same distance to the person. The deployable angles of the IR sensors are from 0 degree to 360 degree with 10 degree interval. Then this will cause 36*36*36 types combination for the three deployment IR sensors. However, we do not have enough computing resources to train a model in all these deployments. In this project, the student should find a solution to train the model in a small number of deployment scenario, while the trained model could cope with the randomly deployed IR sensors.