Projects Related to Observing Elderly

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1) Person Detection, Identification, and Fall Prediction/Detection

These days, smart home healthcare technology has attracted many researchers from different fields such as artificial intelligence, robotics, and computer vision to address peoples' health. For instance, it can support the elderly people living independently in their home with the help of a smart environment. To monitor and analyze human activities based on different sensor data, gait analysis can be a key function. Among the relevant sensors for gait analysis, video sensors are popular for many surveillance applications. For example, a mobile robot in a smart home can detect and analyze the human gait. Thus, it can potentially warn the inhabitant about abnormal gait pattern to pro-actively avoid an accident ahead. Hence, an intelligent gait analysis system can help a person to sustain a healthy life. This project would mainly focus on fall detection and prediction of an elderly living independently at home. Once the fall is detected by a robot, it immediately reports to the caregiver or emergency or both.

Figs. 1.1 and 1.2 show a schematic setup for a mobile robot-based fall prediction and detection systems where the robot monitors an elderly's gait pattern to predict and detect falls. Gait patterns can be analyzed based on video sensors on robot such as Kinect (https://en.wikipedia.org/wiki/Kinect) or Asus 3-D cameras (https://www.asus.com/3D-Sensor/Xtion_PRO/). To detect fall, we can also use floor vibration sensors (http://ieeexplore.ieee.org/document/6531531/).

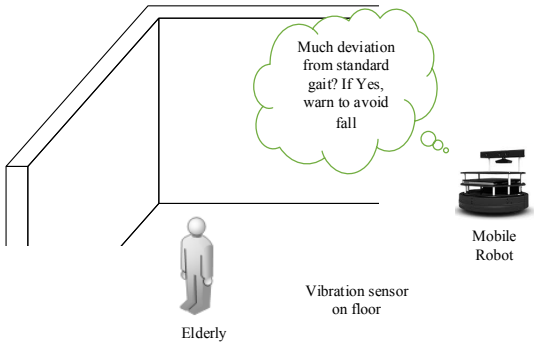

Fig 1.1. A schematic setup of fall prediction using mobile robots.

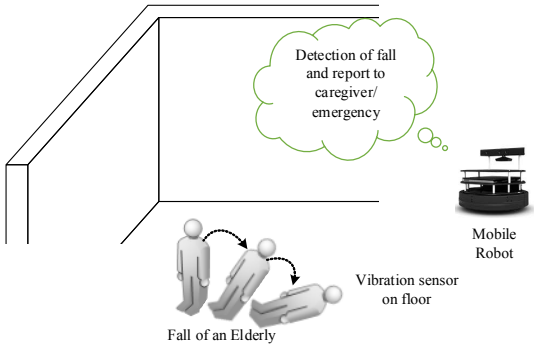

Fig 1.2. A schematic setup of fall detection using mobile robots.

Relevant courses for this project:

- INF4431 - Digital System Design (ROBIN course)
- INF4300 - Digital image analysis
- INF4470 - Digital signalbehandling (signal processing)
- INF4380 - Introduction to robotics (ROBIN course)
- INF5860 - Machine Learning for Image Analysis
- UNIK4590 - Mønstergjenkjenning (Pattern Recognition)
- UNIK4690 - Maskinsyn (machine vision)

2) Vital Sign Monitoring Using Sensors on Robot

Monitoring vital signs is an important component of healthcare and can be done in a medical setting or even at home. In this project, we aim to focus on two important vital signs: respiration and heart beat rate.

Respiration rate is a vital sign that can provide one's general health states and can also be a valuable indicator of underlying medical conditions. A person's respiratory rate is the number of breaths taken per minute. The normal respiration rate for an adult at rest is 12 to 20 breaths per minute and under 12 or over 25 breaths per minute is considered abnormal.

Heart beat rate also provides an assessment of an individual's health status and is an important indicator of cardiovascular disease. Normal heart beat rate for an adult during rest is in the range from 60 to 100 beats per minute. Heart beat rate under 40 per minute during rest should be considered as abnormal.

A popular way to measure the respiration and heartbeat rate is exploiting the signal information obtained by electrodes attached to certain locations of the skin, which seems to be impractical for elderly heartbeat monitoring at home. Hence, we can aim in this project to monitor vital signs of elderly using sensors on robot only such as ultra wide band Xethru sensors (https://www.xethru.com/). Also, sensors on robot should be more practical as the elderly at home can move independently without concern of the location of the sensors.

There are some existing works to obtain respirations and heartrate (e.g., https://www.ncbi.nlm.nih.gov/pmc/articles/PMC4900818/, http://www.mdpi.com/1424-8220/17/2/290).

Moreover, the system can start monitoring the vital signs whenever a person is detected by the robot using presence sensors such as Xethru x4m300 (https://www.xethru.com/x4m300-presence-sensor.html). The works can be concerned with coming up with and implementing a better approach for an accurate vital sign monitoring system.

Fig. 2.1 shows a schematic setup for a mobile robot-based heartbeat and respiration rate monitoring system for an elderly in a smart home.

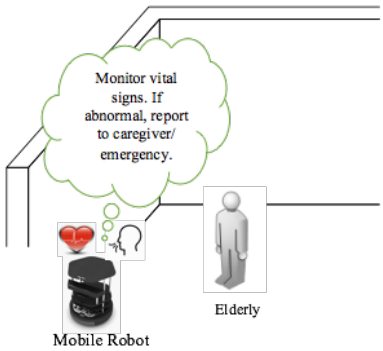

Fig 2.1. A schematic setup of vital sign monitoring using sensors on mobile robots.

Relevant courses for this project:

- INF4431 - Digital System Design (ROBIN course)
- INF4470 - Digital signalbehandling (signal processing)
- UNIK4590 - Mønstergjenkjenning (Pattern Recognition)
- INF4380 - Introduction to robotics (ROBIN course)
- STK4900 - Statistical methods and applications

3) Elderly Behaviour Monitoring Using Ambient Sensors

Many elderly want to spend time in their home environment. A critical aspect in this context is the monitoring and supervision of single elderly person in home. Thus, elderly care at home is a great concern if they stay alone due to unforeseen circumstances may occur to affect their wellbeing. The premise of elderly care applications is expected to be continuous and most often demands realtime monitoring occupant's behaviour using intelligent systems.

In this project, we aim to focus on different ambient sensors such as camera (https://en.wikipedia.org/wiki/Kinect or https://www.asus.com/3D-Sensor/Xtion_PRO/), Xethru presence sensors (https://www.xethru.com/x4m300-presence-sensor.html), floor vibration sensor, or pressure sensors. In case of camera, depth cameras be used so that complexities regarding privacy of an elderly can be minimized. In case of Xethu presence sensors, it can detect the presence of a moving object with the distance of it. Many research works have been done in this field but still, it deserves a lot of research attentions for complex real-time activity monitoring.

Fig. 3.1 shows a schematic setup for a mobile robot-based daily activity monitoring system for an elderly in a smart home.

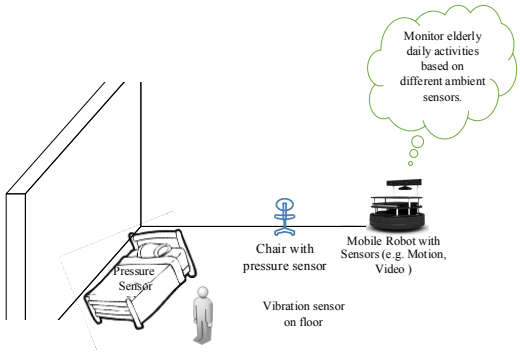

Fig 3.1. A schematic setup of actviity monitoring using ambient sensors.

Relevant courses for this project:

- INF4431 - Digital System Design (ROBIN course)
- INF4300 - Digital image analysis
- INF4470 - Digital signalbehandling (signal processing)
- UNIK4590 - Mønstergjenkjenning (Pattern Recognition)
- INF4380 - Introduction to robotics (ROBIN course)
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4) Emotion Analysis for Affective HRI

Human Robot Interaction (HRI) is one of the most important issues in social robotics. Within HRI, one of the key objectives is the development of methodologies focused on non-invasive techniques based on natural ways. This would allow a robot to interact with a user in a similar way to humans. To socially interact with humans, a robotic system should be able not only to understand the user's behaviour and intentions, but also to estimate his/her emotional state. Understanding human emotions helps a social robot adapting the communication in real-time. This kind of interaction is usually known as affective HRI.

In this project, an emotion recognition system via a multimodal approach can be developed. This system can recognize emotional states of a user (e.g., elderly) through two modalities; visual and auditory. The visual modality uses camera to observe features to recognize facial expressions (https://link.springer.com/chapter/10.1007/978-3-319-44188-7_6, http://dl.acm.org/citation.cfm?id=3006103). The second modality can be the auditory (http://www.tandfonline.com/doi/full/10.1080/02533839.2012.751330). The audio-visual information-based robotic system can determine the emotional state of the user by analyzing the emotional information of a user in a similar way as a human would.

Fig. 4.1 shows a schematic setup for a mobile robot-based emotion recognition for an elderly in a smart home.

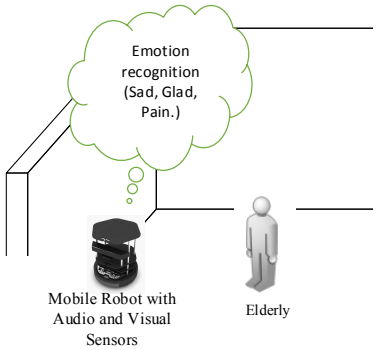

Fig 4.1. A schematic setup of emotion recognition using audio and visual sensors on a robot.

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- INF4431 - Digital System Design (ROBIN course)
- INF4300 - Digital image analysis

- INF4470 - Digital signalbehandling (signal processing)
- UNIK4590 - Mønstergjenkjenning (Pattern Recognition)
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5) Human Recognition in Real-time During Robot Navigation

Among the basic skills of robots at home are the ability to move autonomously, the ability to recognize humans, and interacting with them. This project will focus on human's detection and identification using different sensors such as thermal camera (http://agami.die.uchile.cl/~rverscha/files/JIRS_Correa.pdf), depth camera (https://en.wikipedia.org/wiki/Kinect , https://www.asus.com/3D-Sensor/Xtion_PRO/)), ultra wide band presence (https://www.xethru.com/x4m300-presence-sensor.html), and ultra wide band respiration sensors (https://www.xethru.com/). The robust detection of humans in home environments is a challenging task. Hence, multiple sensors can be used to confirm the existence of human being including the distance from the robot.

Fig. 5.1 shows a schematic setup for a mobile robot-based human recognition during navigation in a smart home.

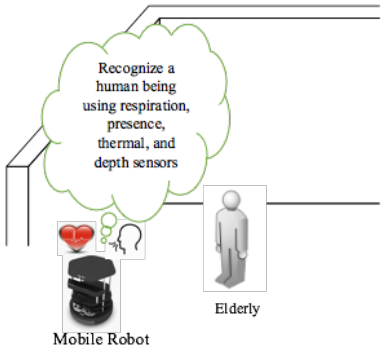

Fig 5.1. A schematic setup of human recognition during navigation using different sensors on a robot.

Relevant courses for this project:

- INF4431 - Digital System Design (ROBIN course)
- INF4300 - Digital image analysis
- INF4470 - Digital signalbehandling (signal processing)
- UNIK4590 - Mønstergjenkjenning (Pattern Recognition)
- INF4380 - Introduction to robotics (ROBIN course)
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