Access Control for Cyber-Physical Systems Using Stereovision and Digital Twins

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1. Research Problem

Protection of Physical Assets Using Cyber Access Control

Protecting physical assets is very important. If a person can get too close to another person or devices that doesn't belong to them, they can cause harm or snoop on information without explicit permission to do so. They have circumvented cyber access control [1]. The majority of modern physical access control systems only limit access at the door to the space, not within the space.

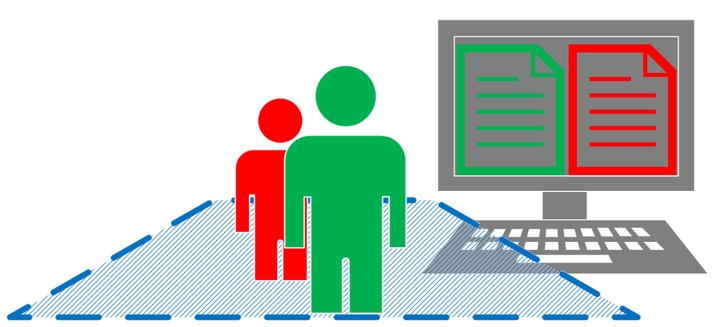

Fig 1: The problem: A person may come into close proximity to other occupants of the space and devices that don't belong to them.

2. Research Solution

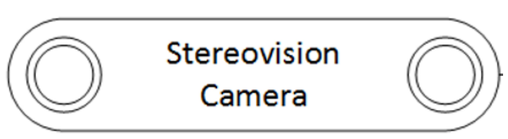

Fig 2: Researchers use a Stereolabs ZED stereovision camera to produce raw images and point clouds to locate objects in a room in 3D space [2]. Point clouds can be used to calculate the distance between people and laptops in the space [3].

Stereovision

Stereovision is a camera system that works like human vision: There are two side-by-side cameras that correlated to one another so that depth information can be calculated.

Image processing techniques can be used to detect and track people and laptops in images produced by the camera's video stream [4][5].

3. Image Processing

Image Processing
Use of a computer to find patterns present in an image.

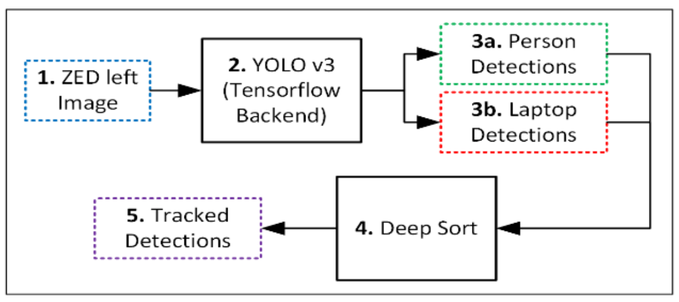

Fig 3: The image processing pipeline used by the researchers to detect and track people and laptops in a space.

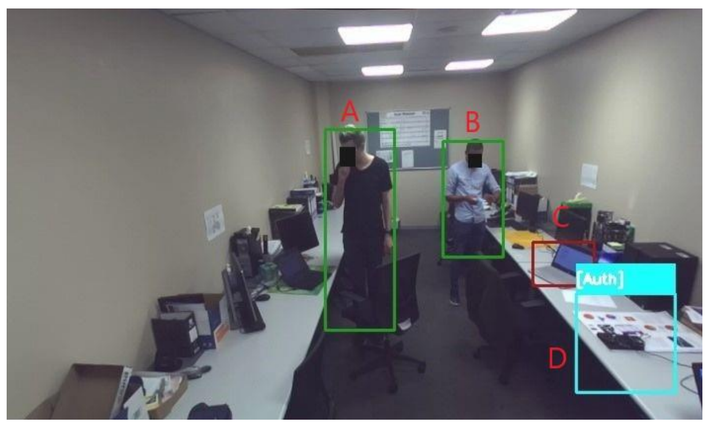

Fig 4: YOLO [4] and Tensorflow [6] are used to process images from a stereovision camera to detect people and laptops

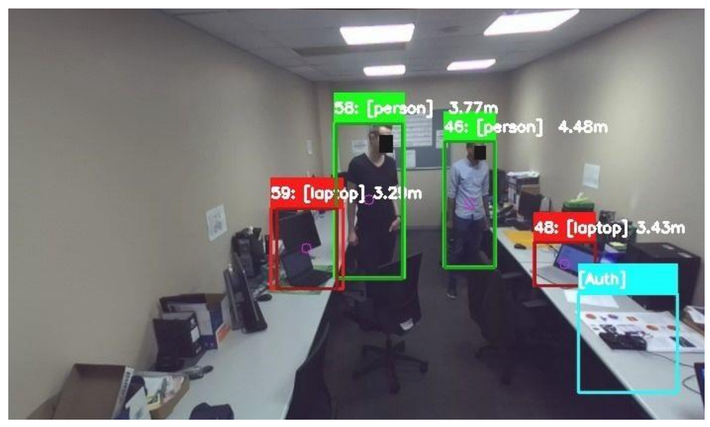

Fig 5: Deep Sort [5] is used to track each person and laptop uniquely as they move about in the space

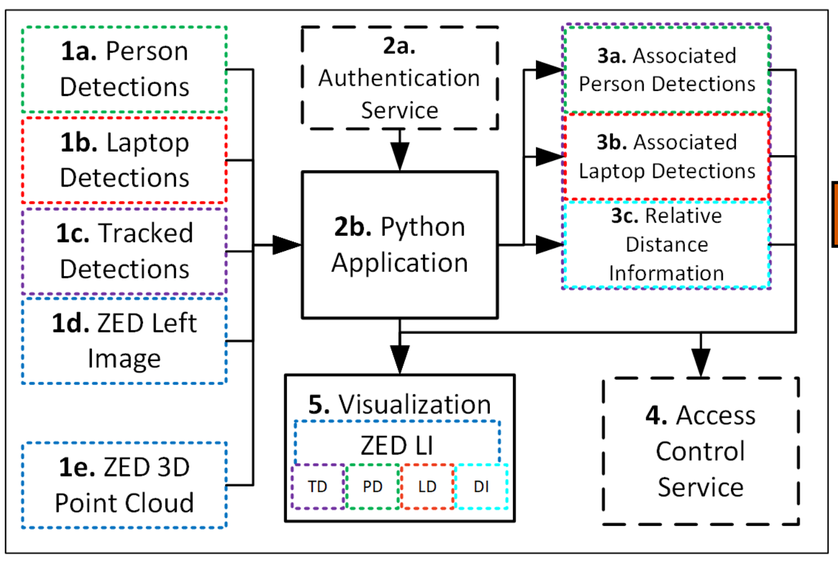

Fig 6: The image processing pipeline developed by the researchers to process information about tracked people and laptops along with 3D point clouds to determine the distances between people and laptops so that access to sensitive information on monitors can be strictly controlled.

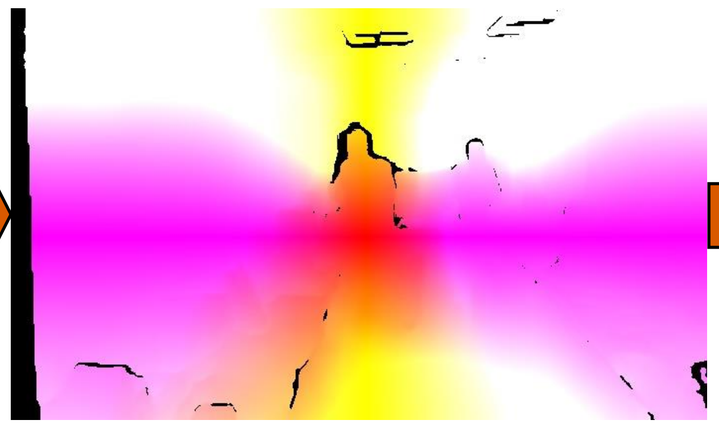

Fig 7: A visualisation of the 3D point cloud from the ZED stereovision camera. This point cloud is related to Fig. 4.

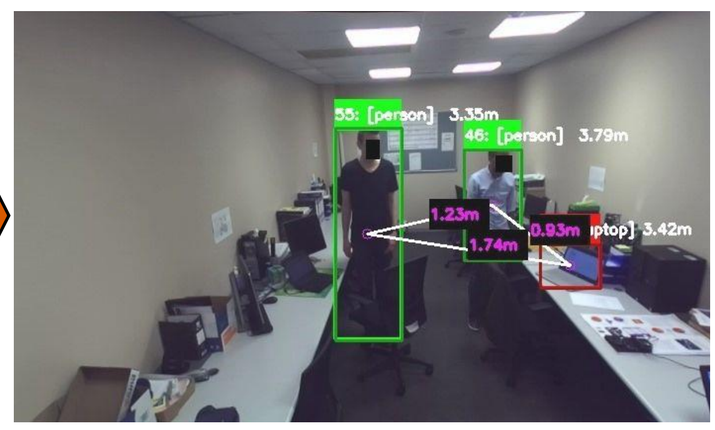

Fig 8: The system uses 3D point cloud information along with Deep Sort tracking information to calculate the relative distance people are from one another and from laptops.

Point Clouds

A Point Cloud is a matrix that contains depth values in the form of 3D space coordinates produced by a depth sensing stereovision camera.

4. Digital Twins and Access Control

Continuous Authentication and using Digital Twins in access control

Authentication is a security service used to prove the identity of someone. Usually this is done by means of a password or some biometric.
This information can be used to produce and maintain Digital Twins. Digital Twins can then be used to manage access control processes.

Digital Twin

Digital Twins are cyber information representations of existing physical entities. For example, the adjacent image shows a digital twin created from an existing human being, John. It shows all the relevant information stored in the system about John and his current state to make decisions.

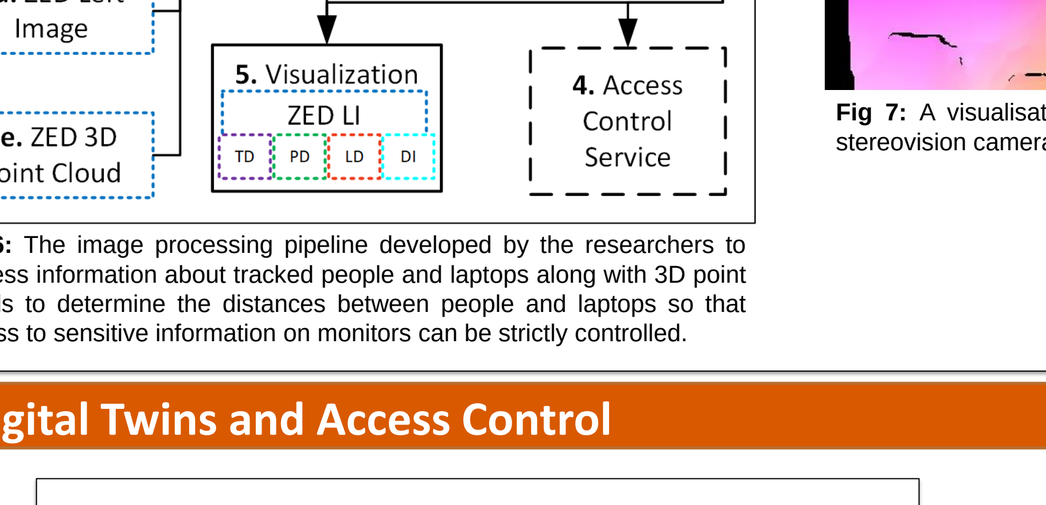

Fig 9: Research architecture to process camera images and perform access control for all people and laptops observed by the camera system.

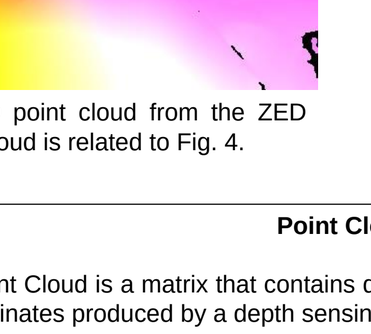

Fig 10: Before access can be controlled, the system needs to know who each tracked person is and which laptop belongs to them. People can authenticate at designated authenticators to associate the person viewed by the camera with their cyber credentials. The system now knows who is in the space.

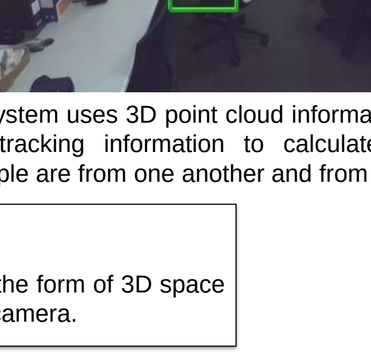

Fig 11: The digital twins report the relative locations of all people and laptops in the space. When someone gets too close to a laptop that isn't theirs, the access control system will decide if preventative measures must be taken such as locking the laptop or sounding an alarm.

5. Conclusion & Future Work

The research has developed an image processing pipeline capable of detecting, tracking, and computing the relative distance between people and laptops in an environment using a Stereovision camera. The system makes use of 3D point cloud make up of Cartesian coordinates that are used in distance computations. Authentication is done by associating Deep Sort tracking ID with the user ID of the closest authenticating person. The same process is followed by the system when associating a laptop with the person logging in. Ongoing tracking information is used for digital twins.

Future Work:

• Create a modular Access Control system to determine what actions need to be performed based on the state of the digital twin and its relative location to other entities in the space.

References

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