Human and object tracking systems for computational dosimetry in Nuclear Medicine

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1. Introduction

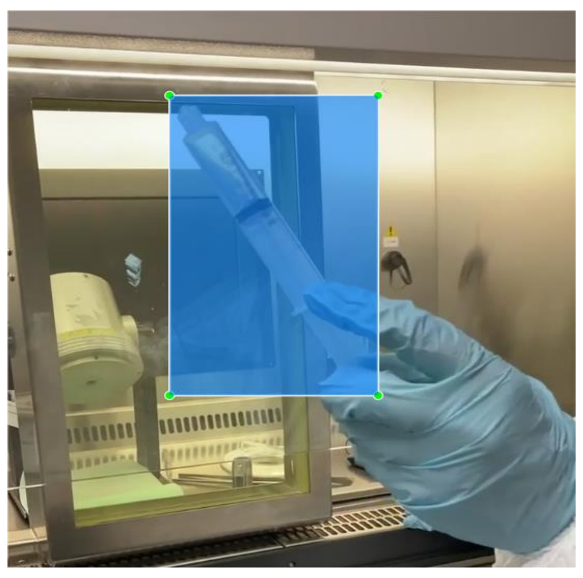
Monte Carlo simulations are used in several dosimetry applications where they can complement or even replace measurements. However, the quality of the simulations heavily depends on the accurate representation of reality using 3D phantoms. In very dynamic environments, where the source is constantly moving, an accurate representation is impossible by using a single simulation setup. This is even more important for staff dosimetry in nuclear medicine, during the preparation and administration of radiopharmaceuticals. The constant movement of the radiation source and the hands, demands not only an accurate representation but also running consecutive simulations to represent the entirety of the manipulations. For that purpose, all the positions of the source and postures of the hands should be registered and recreated using 3D models.

2. Objectives

Improve the accuracy of Monte Carlo Simulations for dose assessment in Nuclear Medicine by creating a framework able to represent accurately the dynamic movements of the source and the hands of workers.

3. Methods

Using digital cameras and the latest computer vision techniques, two different algorithms were implemented to identify the posture and position of hands and syringes of Nuclear Medicine staff.

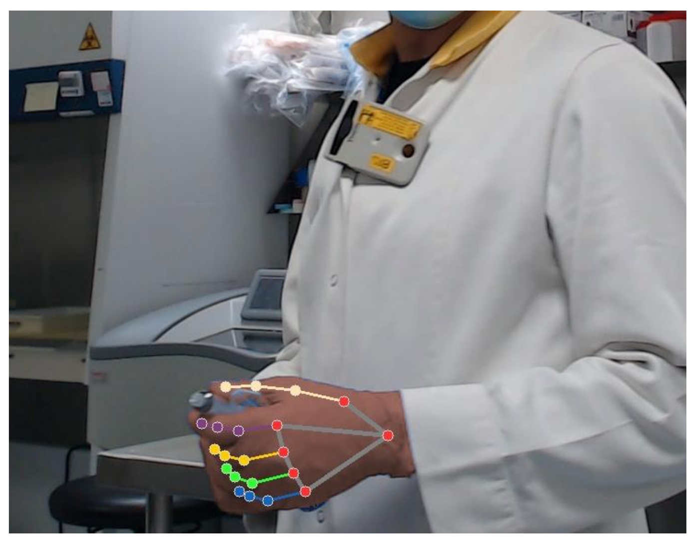


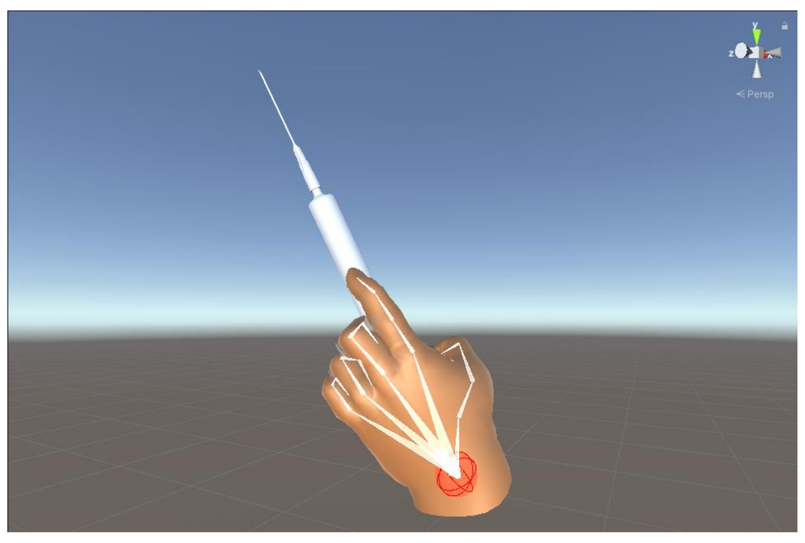
Syringe detection

A Neural Network was trained using TensorFlow to identify syringes in the hands of the staff. More than 15000 images of syringes were used for the training. A software was developed to partially automatize the annotation process.

Hands detection

For the personnel tracking, two different frameworks for identifying human postures (OpenPose and MediaPipe) were compared by weighing computational efficiency and accuracy. Some further improvement was done to correctly identify the position of the fingers, since both frameworks showed color sensitivity and were unable to recognize the colored laboratory gloves at first.

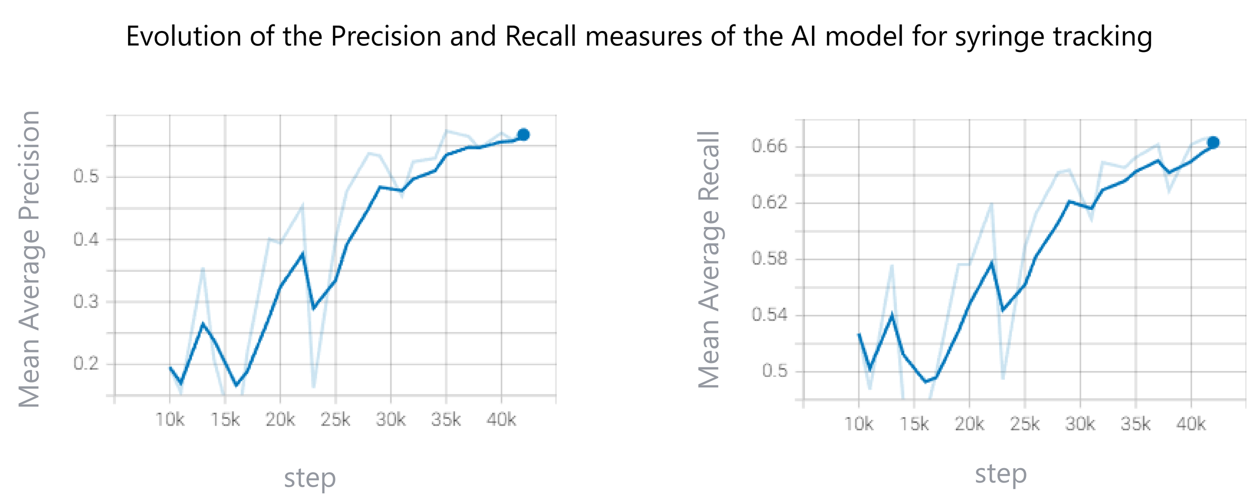


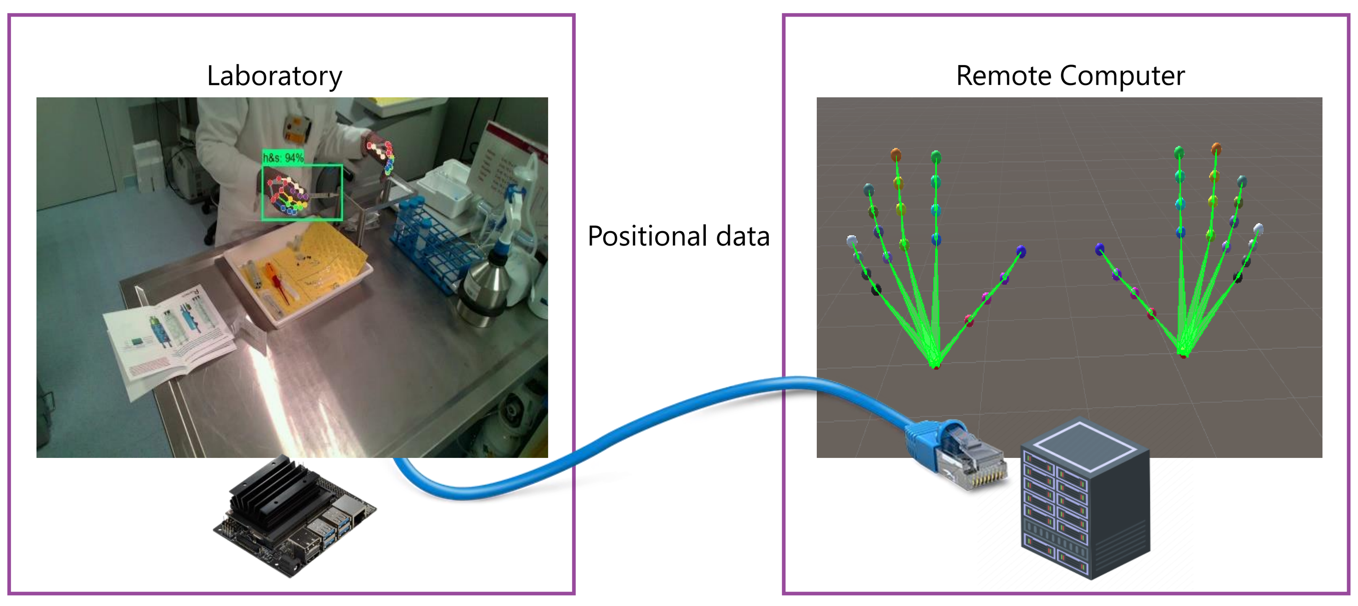


3D representation

Unity game engine was used to represent the 3D hands in the identified positions, performing the necessary calculations to deform, rotate and translate the meshes.

4. Results





The neural network model trained for syringe detection was an SSD MobileNet v2 320x320 and achieved 0.57 mean Average Precision and 0.61 mean Average Recall after 40K steps. This measures are commonly used to validate trained models and are in the range of accepted values for the AI community.

The accuracy of the person tracking frameworks was similar, but MediaPipe has a much lower computational cost. Therefore this model was selected.

The hand tracking algorithm was linked to Unity using a network interface that sends the positional data of the hands to a powerful computer where the 3D models are constantly regenerating to adopt the position of the hands in real time and generates the MC input files.

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5. Conclusions and further work

The tracking systems will allow more accurate MC simulations, since they are able to assess the position of hands and sources in a NM laboratory in real-time. A system to automatically generate, second by second, all the necessary 3D models and adjust them to the monitored positions is being created as a complement to this tracking systems in order to automatically generate MC simulations.

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