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CREATION OF A VIRTUAL TRAINING CRYOLABORATORY

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Research relevance. Innovative approaches in education are becoming increasingly important in the context of rapid advancements in science and technology. One of the critical aspects of the modern educational process is the use of 3D visualization technologies, which open up new horizons in the field of learning, especially in technical and natural sciences. In biomedical engineering, which combines medical and engineering knowledge, 3D visualization provides a unique opportunity to model complex processes and structures, such as anatomical organs, cellular systems, and biological processes. This is of great significance in the context of creating virtual laboratories, particularly educational cryolabs. Access to specialized laboratory equipment can be limited due to current realities such as the pandemic, political situations in the country (including war or active combat), and insufficient funding (stemming from poor financing or the overall financial situation of the country). This necessitates the implementation of remote learning models, visual guidance, and the effect of personal presence using 3D technologies to replicate laboratory practice [1].

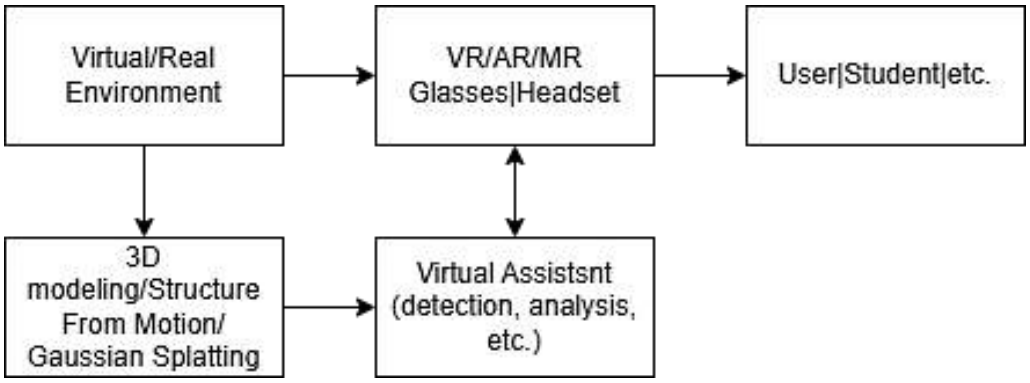

Figure 1 – A generalized diagram of user interaction with a virtual assistant [1]

Research goal. The research aims to develop a deep learning convolutional model for a cryolab using Convolutional Neural Networks, a powerful tool for object detection. This virtual assistant has accurately identify objects, analyze their states, provide students with the necessary information for successful experimentation, and help train safety techniques. The system must be compatible with mixed, augmented, and virtual reality platforms (Apple Vision, Meta Quest 3).

Main research materials. For the project, a Canon EOS M50 Mark II was used to capture photos (6000x4000, 24MP) and videos (1280x720) in RGB color space, with a DJI Ronin SC stabilizer for steady shooting. To optimize neural network training, frame-by-frame images were taken at the highest frame rate without duplicates, accurately capturing the contours and details of devices. Data collected includes 400 photos and 10 videos of equipment at the Leibniz University Hannover's Institute for Multiphase Processes, with a balanced dataset enabling accurate detection and classification. 80% of the data was used for training and 20% for testing. Images were annotated in Labelme [2], creating around 100 instances per each of the 11 object classes. The dataset, structured in COCO-style JSON annotations, includes image paths, dimensions, IDs, and annotations with bounding boxes, labels, and segmentation masks (polygons or RLE). Using this data, multiple convolutional neural network models were trained in Detectron2 [3] to detect and classify equipment from various distances and angles. The RCNN models were compared based on Total Loss,

Classification Loss, False Negative Rate, and Training Time. The most relevant model, faster_rcnn_R_101_FPN_3x, was selected for further work. Using Detectron2 and PlayCanvas [4], a virtual environment was created to replicate the cryolab.

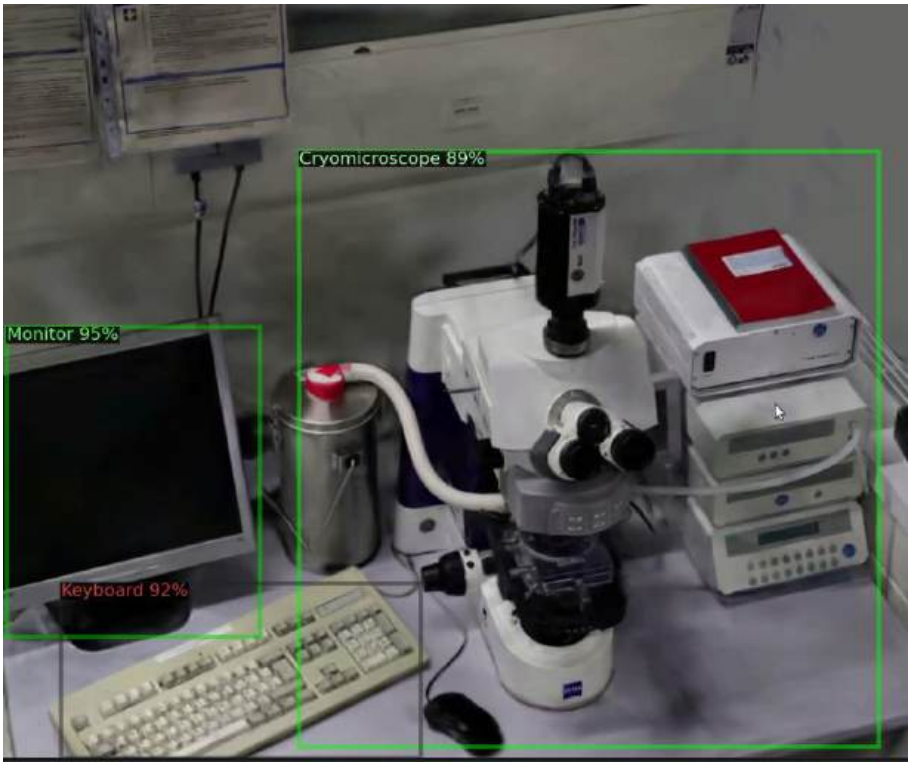

Figure 2 – Result of equipment detection in the recreated virtual environment

Conclusion. Data was collected from 400 photos and 10 videos, and three object detection models based on the R-CNN architecture were trained using the Detectron2 framework. Their strengths and weaknesses were identified by comparing the models using metric data. Consequently, suitable areas for the use of these models were forecasted. The created system accurately reflects the working environment. As a virtual assistant, it is highly effective in offering guidance during standard cryo lab procedures. Moreover, the results suggest that this technology holds promise for integrating mixed, augmented, and virtual reality platforms, like Apple Vision and Meta Quest 3, for educational purposes.

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