Human Pose Detection in 3D with Deep Learning and RGB-D Cameras

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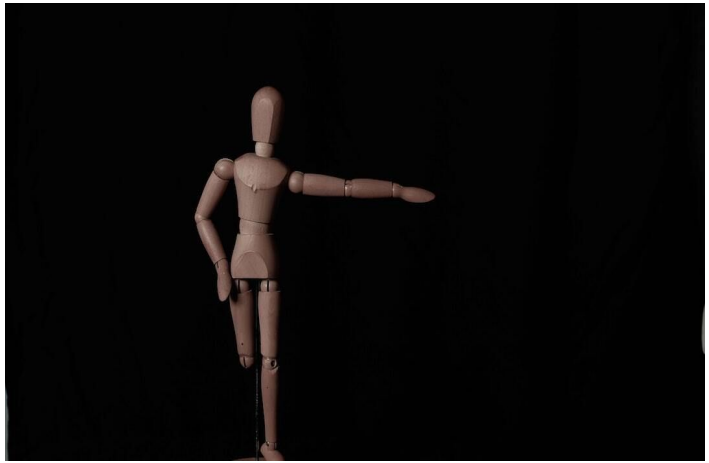
Enabling Human-Robot Interaction in Dancing

- **Overview:** Exploring the integration of MediaPipe and Intel RealSense for advanced 3D human pose detection. Focused application in human-robot interaction for dancing.
- **MediaPipe Framework:** https://github.com/google/mediapipe Utilizes machine learning to facilitate real-time hand and pose tracking. Essential for interpreting complex human movements in 3D space.
- **Intel RealSense Technology:** Provides depth sensing and 3D vision capabilities. Enhances accuracy in detecting and mapping human movements.
- **Application in Dancing:** Enables robots to perceive and mimic human dance movements, creating interactive and responsive dance partners.



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Technical Details of MediaPipe and Intel RealSense Integration

Enhancing 3D Human Pose Detection

- **MediaPipe Mechanics:** Employs a complex pipeline of machine learning models for pose estimation. Processes visual data from multiple sources, including Intel RealSense cameras.
- **Intel RealSense's Role:** Offers depth data and infrared imaging. Crucial for enhancing the 3D spatial perception capabilities of MediaPipe.
- **Real-Time Processing:** Integration allows for real-time interpretation of complex dance movements. Key for dynamic and responsive human-robot dancing interaction.
- **Accuracy and Precision:** Combination ensures high accuracy and precision in pose detection. Essential for nuanced dance movements and synchronization with a robotic partner.

Code Implementation and Live Demo

Human-Robot Dance Interaction

- **Code Overview:** Python script integrates MediaPipe and Intel RealSense for 3D pose detection. Configures streams, initiates MediaPipe Pose, and uses RealSense depth data.
- **Real-Time Landmark Detection:** Script captures and processes video frames in real-time. Extracts pose landmarks and overlays them on RGB images for visual verification.
- **3D Coordinates Extraction:** Combines color and depth information to calculate precise 3D coordinates for each landmark. Displays these coordinates on the live feed.
- **Demo Application:** Demonstrates the practical use of the script with a live dance interaction scenario, showcasing human-robot synchronization.

Challenges in Choreography and Robot-Human Synchronization

Innovating Dance Partnerships

- **Choreography Design:** Creating dance sequences that can be interpreted and performed by robots in sync with humans. Requires understanding of motion dynamics and robot capabilities.
- **Synchronization Issues:** Addressing latency and precision in robot movements to match human dancers. Essential for seamless and coordinated dance performances.
- **Utilizing UNITREE Robots:** Leveraging the capabilities of UNITREE robots (https://dev-z1.unitree.com/ and https://github.com/unitreerobotics/unitree_ros/tree/master/robots) known for their agility and human-like movement patterns.
- **Real-World Application:** Applying these technologies in live performances showcases the potential of advanced robotics and AI in entertainment and beyond.

Choreography Innovation for Limited Spaces

Maximizing Visibility for Pose Detection

- **Space-Conscious Choreography:** Designing dance moves that fit within confined areas while ensuring the dancer's full body is in the camera's view for accurate pose detection.
- **Creative Movement Solutions:** Utilizing vertical space and layered positioning to maximize the use of limited floor space. Incorporating poses that maintain visibility of all limbs.
- **Visibility and Pose Detection:** Choreography must facilitate unobstructed visibility of key movement points to ensure accurate pose detection and analysis by the system.
- **Interaction Dynamics:** Crafting choreography that allows for interactive elements with the robot, considering its range of motion and response time.

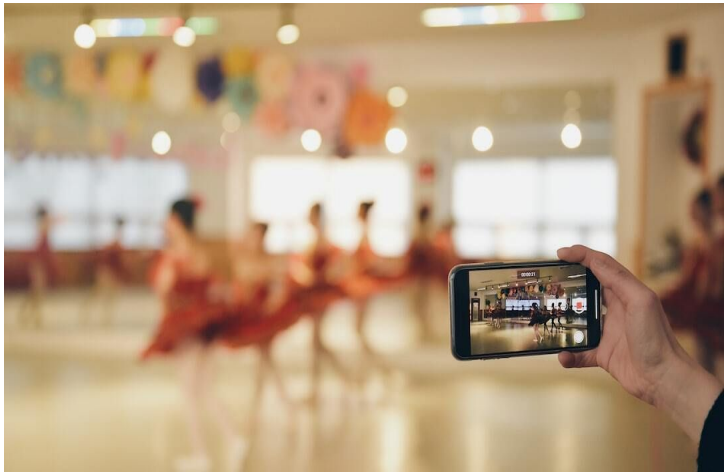
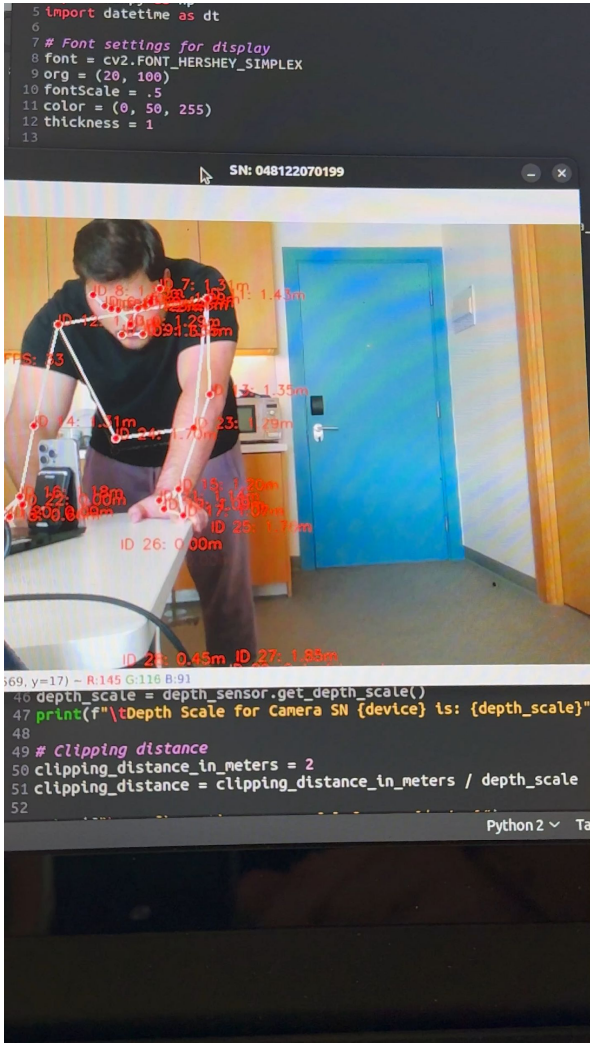


Photo by Suhyeon Choi on Unsplash

3D Human Pose Demo

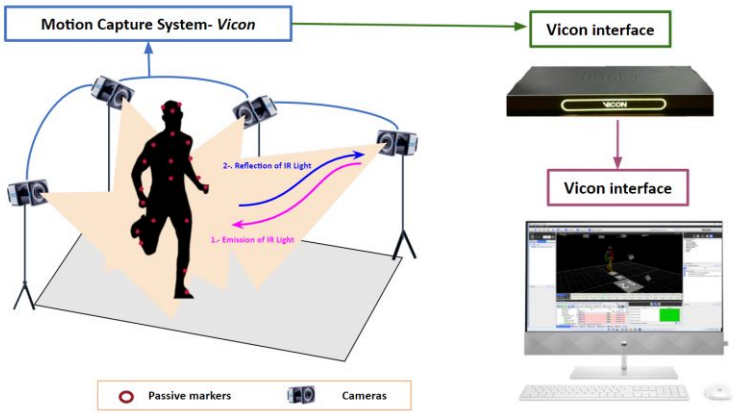
Use https://www.intelrealsense.com/depth-camera-d455/
RGB-D camera

Features	**Use environment:** Indoor/Outdoor	**Ideal Range:** .6 m to 6 m
	Image sensor technology: Global Shutter	**Inertial measurement unit:** Bosch BMI055
Depth	**Depth technology:** Stereoscopic	**Depth Field of View (FOV):** 87° × 58°
	Minimum Depth Distance (Min-Z) at Max Resolution: ~52 cm	**Depth output resolution:** Up to 1280 × 720
	Depth Accuracy: <2% at 4 m[1]	**Depth frame rate:** Up to 90 fps
RGB	**RGB frame resolution:** Up to 1280 × 800	**RGB sensor FOV (H × V):** 90 × 65°
	RGB frame rate: 30 fps	**RGB sensor resolution:** 1 MP
	RGB sensor technology: Global Shutter	

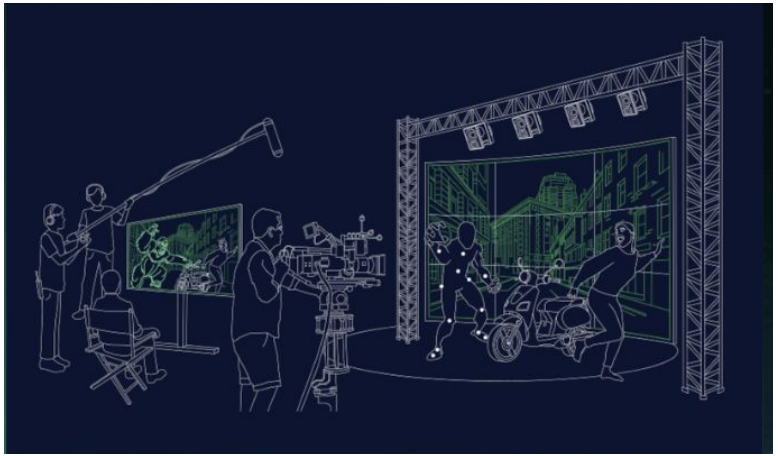


3D Human Pose Alternatives

Use Nexus for Vicon Motion Capture System
https://www.vicon.com/software/nexus/



Use Shogun for Vicon Motion Capture System https://www.vicon.com/software/shogun/



Objective

1. Submit an article to ArtsIT Conference https://artsit.eai-conferences.org/2024/ [Deadline June 15]
2. Present this article in November 2024

Next Steps

1. Decide on RGB-D or use of Motion Capture System (today)
2. Record dance by human-leader (by April 9)
3. Record 3D-pose of human-leader (by April 11)
4. Suggest robot motion based on Haussdorf distance metric (by April 15)
5. Robot Choreography, others, music…
6. Multiple cameras