VIRTUAL REALITY AND MIXED REALITY

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VIRTUAL REALITY

Virtual Reality applications are computer-based simulations where one or more users can interact with an imaginary immersive realistic-looking 3D environment.

- The computer graphics is used to create a virtual environment.
- The environment should respond to user's inputs giving real time feedbacks to the player, for example modifying the world or its content instantaneously.
- The vr environment can be imaginary or a realistic, depending on the final use (video-games, simulators, cultural heritage apps, vr-films, etc)

VIRTUAL REALITY

VR environments ideally can involve all the senses, currently vr headsets and vr devices can involve audio, video, and haptic feedback.

Image from https://www.ultraleap.com/company/news/blog/what-is-haptic-feedback/

AUGMENTED REALITY (MIXED)

Augmented Reality applications are used to put additional virtual elements on the real world.

The virtual elements can include images, buttons and texts.

The ar app can be used for different purposes, from entertainment, as video-games, to business, as an ar app labeling objects or an ar app supporting marketing.

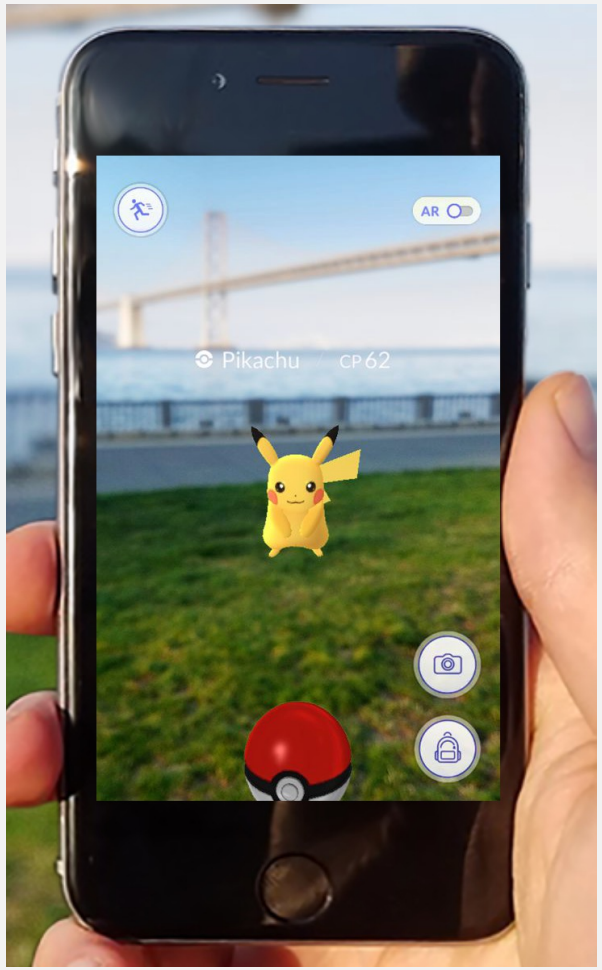


Image from https://pokemongolive.com/it/

AUGMENTED REALITY (MIXED)

Augmented Reality app can be developed for mobile phones or for xr headsets as Microsoft HoloLens [1].

Frameworks:

- Android: ARCore [2]
- iOS: ARKit [3]
- Unity: ARFoundation [4] supporting ARCore and ARKit XR plugins, and Windows XR plugin for HoloLens
- Vuforia SDK [5], supports both native Android / iOS and Unity AR development

1. https://www.microsoft.com/it-it/hololens
2. https://developers.google.com/ar
3. https://www.apple.com/it/augmented-reality/
4. https://docs.unity3d.com/Packages/com.unity.xr.arfoundation@4.1/manual/
5. https://developer.vuforia.com/downloads/sdk

VR LOCOMOTION AND VR SICKNESS

MOTION SICKNESS

The motion sickness indicates a feeling of discomfort or illness felt by a human being, that can occur when there is a difference between the expected and the actual motion performed by the human.

In other terms, motion sickness may occur when different (not coherent) information comes from the eyes and from the equilibrium system.

In real life motion sickness can occur while traveling with cars, trains, planes, etc.

Motion sickness can also occur while wearing virtual reality headsets, as the motion in the virtual environment does not correspond to a motion in the real world.

MOTION SICKNESS

Other causes of vr motion sickness can be the latency between the head movement and the movement reflection in the virtual world, or the fatigue of using a vr headset [1], [5].

VR motion sickness is also labeled as VR sickness or Cybersickness.

The reported incidence of cybersickness amongst users of VR is varied, but it is generally accepted that, at least, 60% of participants in a first VR experience will suffer its symptoms to some degree, and although most users adapt to the environment after few immersions, approximately 5% will never do so [1]

VR MOTION

To avoid or reduce the risk of motion sickness, different types of first-person virtual locomotion have been explored, here some [2] [3] [4]

- Joystick or Indirect Locomotion
  The player can move the avatar forward by pressing the joystick, this method is similar to the input of classic games' controllers

- Teleporting or Free teleport
  The player, holding a controller's button, can point to a specific position nearby, on the ground and jump instantaneously to that location when he/she releases the button (or press another button).

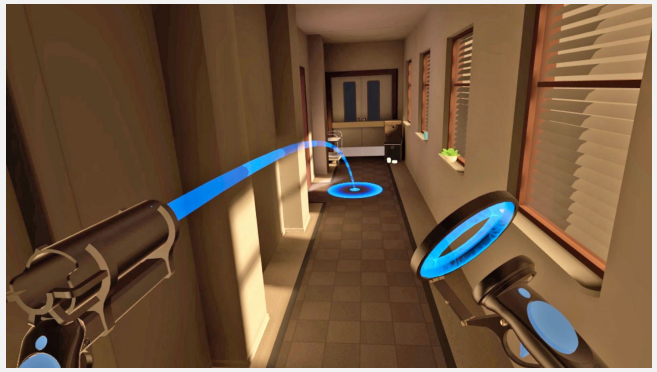
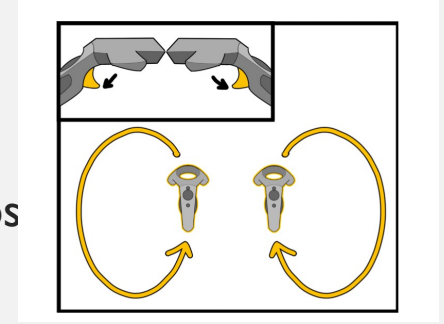


Image 1 from https://www.oculus.com/rift/accessories/?locale=it_IT
Image 2 from https://medium.com/vrdojo/teleportation-or-sliding-locomotion-methods-wont-stop-room-scale-vr-37c6c77761d9

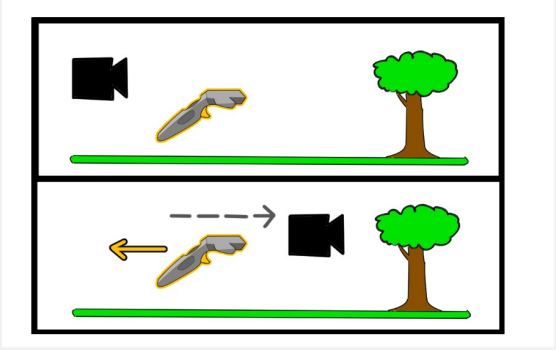
VR MOTION

(Continue) [2] [3] [4]

- Arm-Cycling or Arm swinging
  The player can perform (while holding the controllers) circular movements of the arms simulating walking steps



- Point-Tugging
  When the user holds a controller's button or makes a movement, the avatar translates nearby along an axis (for example the player's gaze direction).



Images 1 and 2 from [2]

VR MOTION

(Continue) [2] [3] [4]

- Walking
  The player and him/her movements are tracked

- Walking in place
  The player and him/her movements are tracked (for example through accelerometer sensors) to recognize walk in place

Image from [4]

DOF – DEGREES OF FREEDOM

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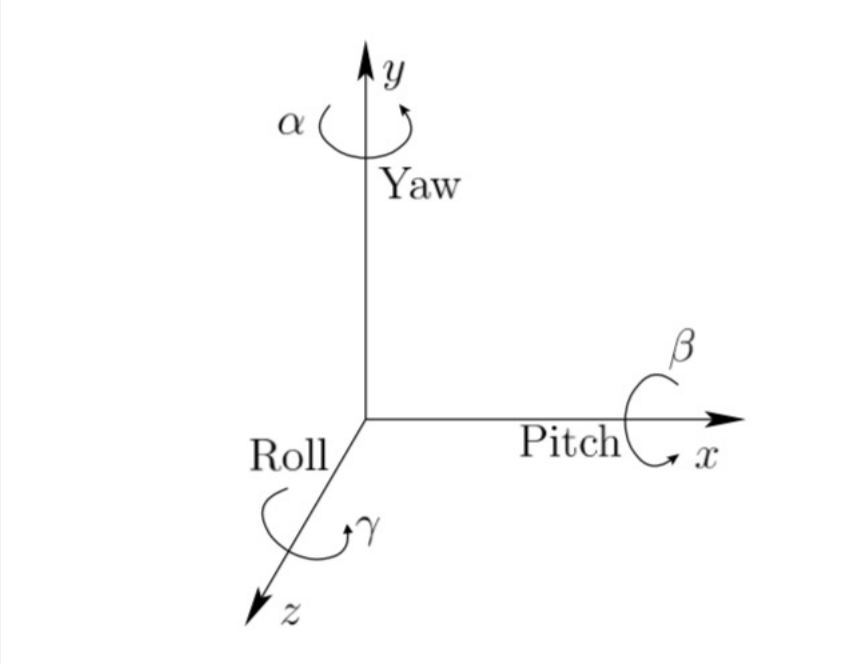
The term *degrees of freedom* (DOF) refers to the possible movements of a rigid body inside the space.

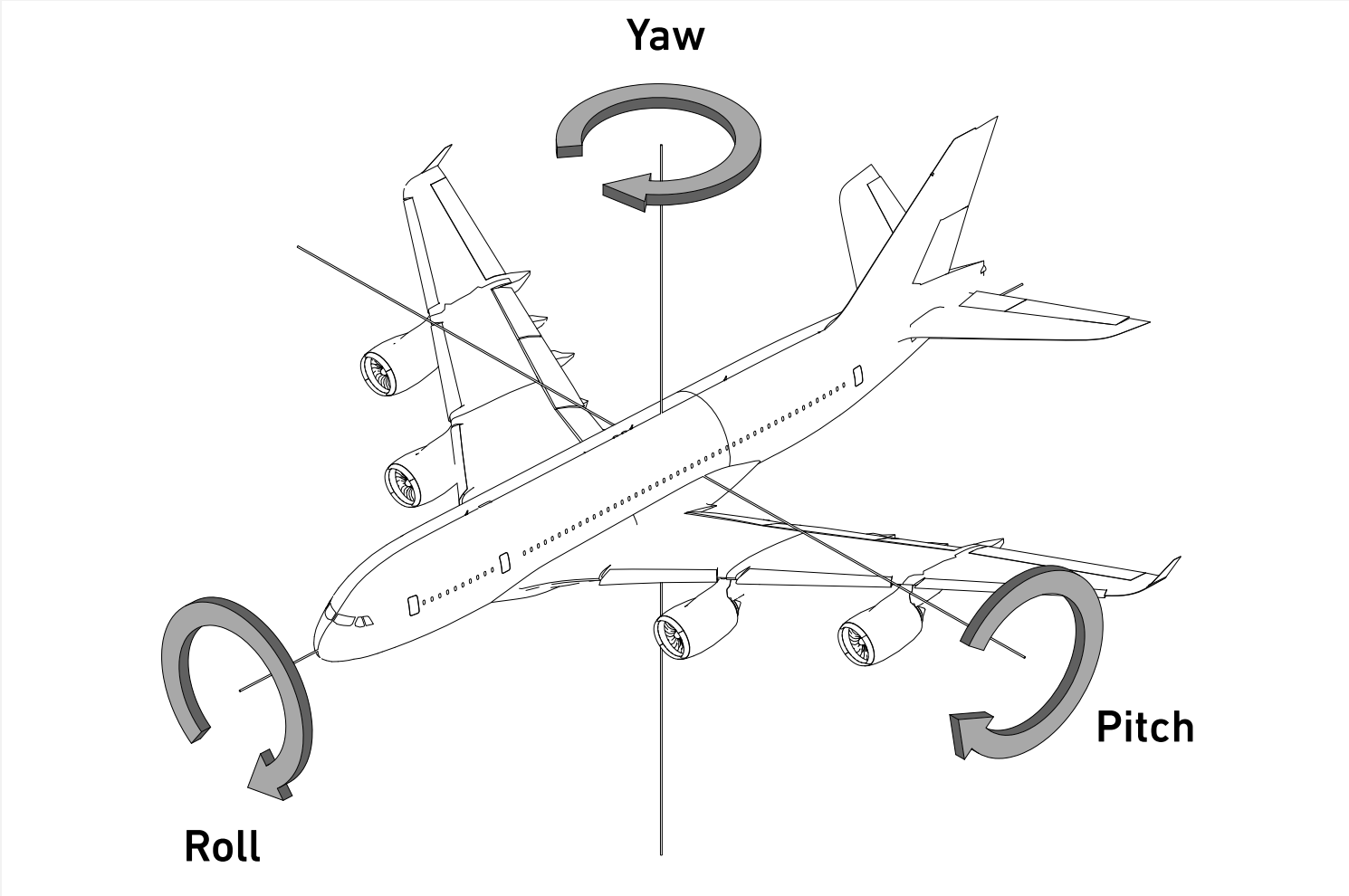
The DOF are counted as the number of rotational axes on which the object can rotate + the number of axes in which direction the object can move.

In the 3D world without constraints a body has **6 DOF** in total (3+3):

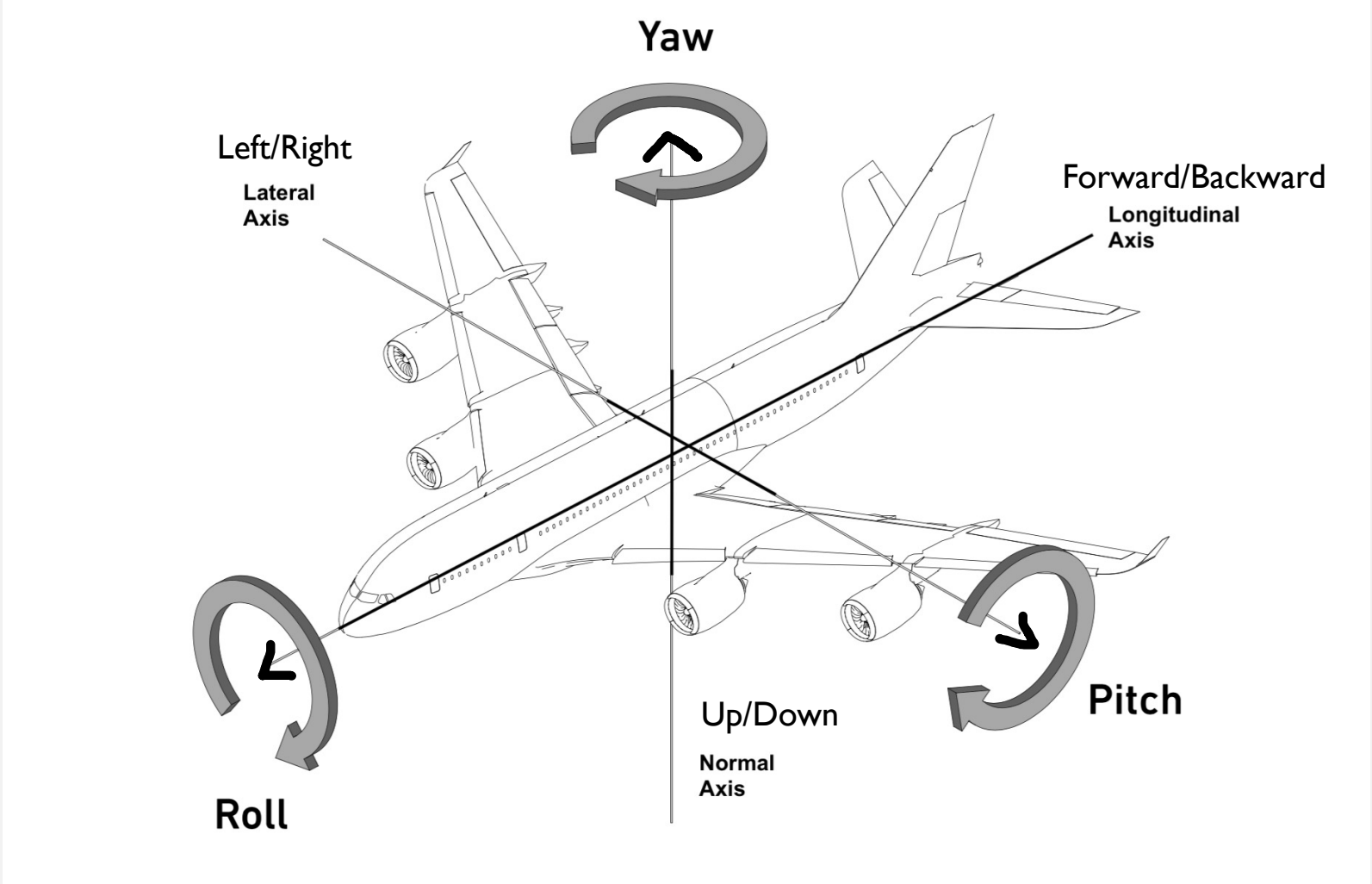
3 DOF indicating body translations and 3DOF indicating body rotations.



ROTATION AXES



ROTATION AND TRANSLATION AXES



VR POSITIONAL TRACKING

Positional Tracking is exploited to detect object's position and rotation in the real word, as the headset, the player's hands or the joypads, etc.

VR Positional Tracking is used to track and translate the player's real-world movements into the virtual environment.

For example, it can be used to convert the walk gesture performed in the real world into a walk translation in the virtual world.

VR Positional tracking can be performed only of VR devices with 6DOF tracking capabilities [6][7]

Therefore, VR Positional Tracking is fundamental also to reduce Motion Sickness.

Through Positional Tracking, in fact, the player's movements in real life (with the 6DOF) are tracked in order to be represented in the virtual environment, reducing the discrepancy between the perceived movements of the equilibrium system and what is seen through the eyes.

3DOF VS 6DOF OF VR HEADSETS

DOF are used in VR to track the movements along the axes that are monitored by the VR input hardware devices.

- 3DOF for VR Headsets indicates that the head movements are tracked along the rotation axes (Roll, Pitch, Yaw).
  Headsets with 3DOF are:
  - Google Cardboard
  - Oculus Go
- 6DOF for VR Headsets means that the head movements are tracked along the rotation axes and along the directional axes (Roll, Pitch, Yaw - X, Y, Z).
  Headsets with 6DOF are:
  - Oculus Rift
  - HTC Vive
  - Hololens (XR headset)

3DOF VS 6DOF OF VR HEADSETS

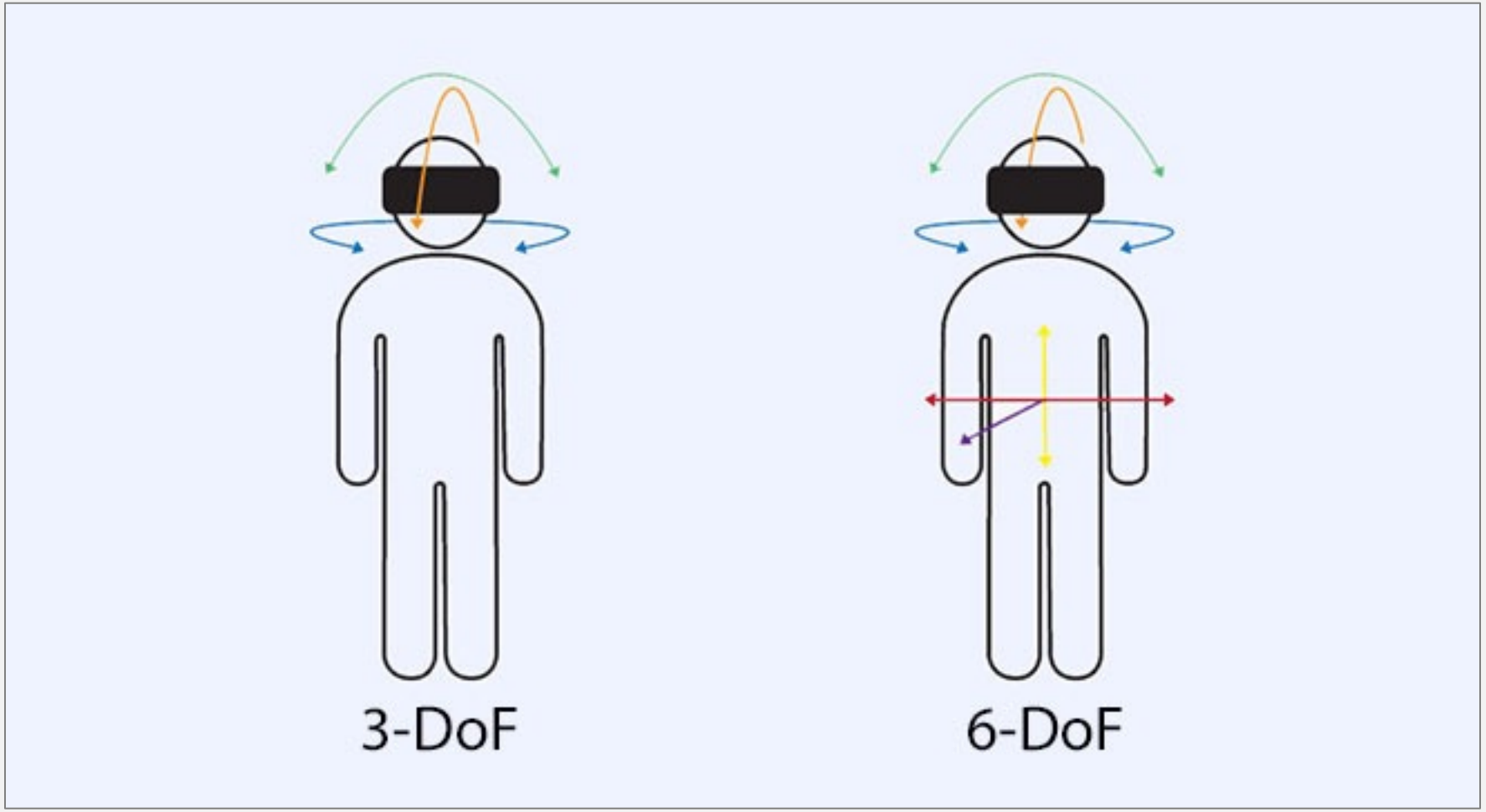


Image showing the difference between 3-DoF (rotational movement) and 6-DoF (rotational and translational movement) with a VR headset.
From https://virtualspeech.com/blog/degrees-of-freedom-vr (visited on 06 april 2021)

REFERENCES

- [1] Garcia-Agundez A., Westmeier A., Caserman P., Konrad R., Göbel S. (2017) An Evaluation of Extrapolation and Filtering Techniques in Head Tracking for Virtual Environments to Reduce Cybersickness. In: Alcañiz M., Göbel S., Ma M., Fradinho Oliveira M., Baalsrud Hauge J., Marsh T. (eds) Serious Games. JCSG 2017. Lecture Notes in Computer Science, vol 10622. Springer, Cham. https://doi.org/10.1007/978-3-319-70111-0_19
- [2] Coomer, Noah & Bullard, Sadler & Clinton, William & Williams, Betsy. (2018). Evaluating the effects of four VR locomotion methods: joystick, arm-cycling, point-tugging, and teleporting. 1-8. https://doi.org/ https://doi.org/10.1145/3225153.3225175
- [3] Julian Frommel, Sven Sonntag, and Michael Weber. 2017. Effects of controller-based locomotion on player experience in a virtual reality exploration game. In Proceedings of the 12th International Conference on the Foundations of Digital Games (FDG '17). Association for Computing Machinery, New York, NY, USA, Article 30, 1–6. DOI: https://doi.org/10.1145/3102071.3102082
- [4] Preston Tunnell Wilson, William Kalescky, Ansel MacLaughlin, and Betsy Williams. 2016. VR locomotion: walking > walking in place > arm swinging. In Proceedings of the 15th ACM SIGGRAPH Conference on Virtual-Reality Continuum and Its Applications in Industry - Volume 1 (VRCAI '16). Association for Computing Machinery, New York, NY, USA, 243–249. DOI: https://doi.org/10.1145/3013971.3014010
- [5] 12.3 "Comfort and VR Sickness" chapter from Virtual Reality Steven M. LaValle http://vr.cs.uiuc.edu/vrbookbig.pdf
- [6] https://www.roadtovr.com/introduction-positional-tracking-degrees-freedom-dof/ (visited on 06 april 2021)
- [7] https://developer.oculus.com/learn/bp-orientation-tracking/?locale=it_IT (visited on 06 april 2021)