The weekly recap of what is going on in the world of biomechanics.

Markerless Motion Capture Systems

Motion capture systems that are not marker-based (“Markerless Motion Capture Systems” – MLS) are moving further and further into the limelight. Why is relatively obvious: Marker-based systems, such as Vicon or Qualisys, are very expensive and measurements are very time-consuming if you take into account the calibration, the attachment of the markers, the capturing itself and the post-processing. MLS could help out here.

In this context, the Kinect v2 system developed by Microsoft for the Xbox video game console has become the focus of particular attention. The system was first presented in 2009 at a new price of $150 (approx. 135€) and consists of an RGB camera and an infrared-based depth sensor. Its original purpose was to control video games using gestures and movements. But already in 2010 the system was discovered for scientific purposes. Scientists, engineers and hobbyists hacked the system so that it could also be connected to a PC via a USB interface to retrieve the raw data. This laid the foundation for the Kinect’s wide range of applications outside the entertainment sector.

For example, Kinect has been used in robotics to enable robots to determine the shape and approximate distances to obstacles through depth sensing, so that they could bypass them. And now we come to the interesting part for us as biomechanists: the system can also be

used to quantify the posture and movement of living bodies.

But how high is the accuracy of a game controller? Is the Kinect suitable for scientific purposes?
There are already a number of studies on the validity and reliability of the Kinect system, a few of which are listed below in the References. The most recent of these was published in the Journal of Biomechanics last week and is still in the pre-proof stage. This means that the article has already been nodded off by other scientists to ensure high quality, but it is not yet the final version of the paper. We have also looked at the study for you:

Reliability of a markerless motion capture system to measure the trunk, hip and knee angle during walking on a flatland and a treadmill

The authors of the study, Ryo Tanakaa, Hiroyuki Tamurab and Hiromichi Kawanishic, found during their literature research that problems with the kinetic data can occur at different periods of gait analysis with Kinect v2. This led them to determine and understand the accuracy and reliability of the system over an entire gait cycle.

To do so, they let 22 young and injury-free participants (20.9 ± 0.3 years, 13 male and 9 female) walk several times on two different days at 2 mph on a treadmill as well as on normal ground. The gait was standardized using markings on the floor as well as a metronome and recorded it with Microsoft Kinect v2. The system recorded at 30 Hz and the skeleton model was taken directly from the official Software Development Kit.

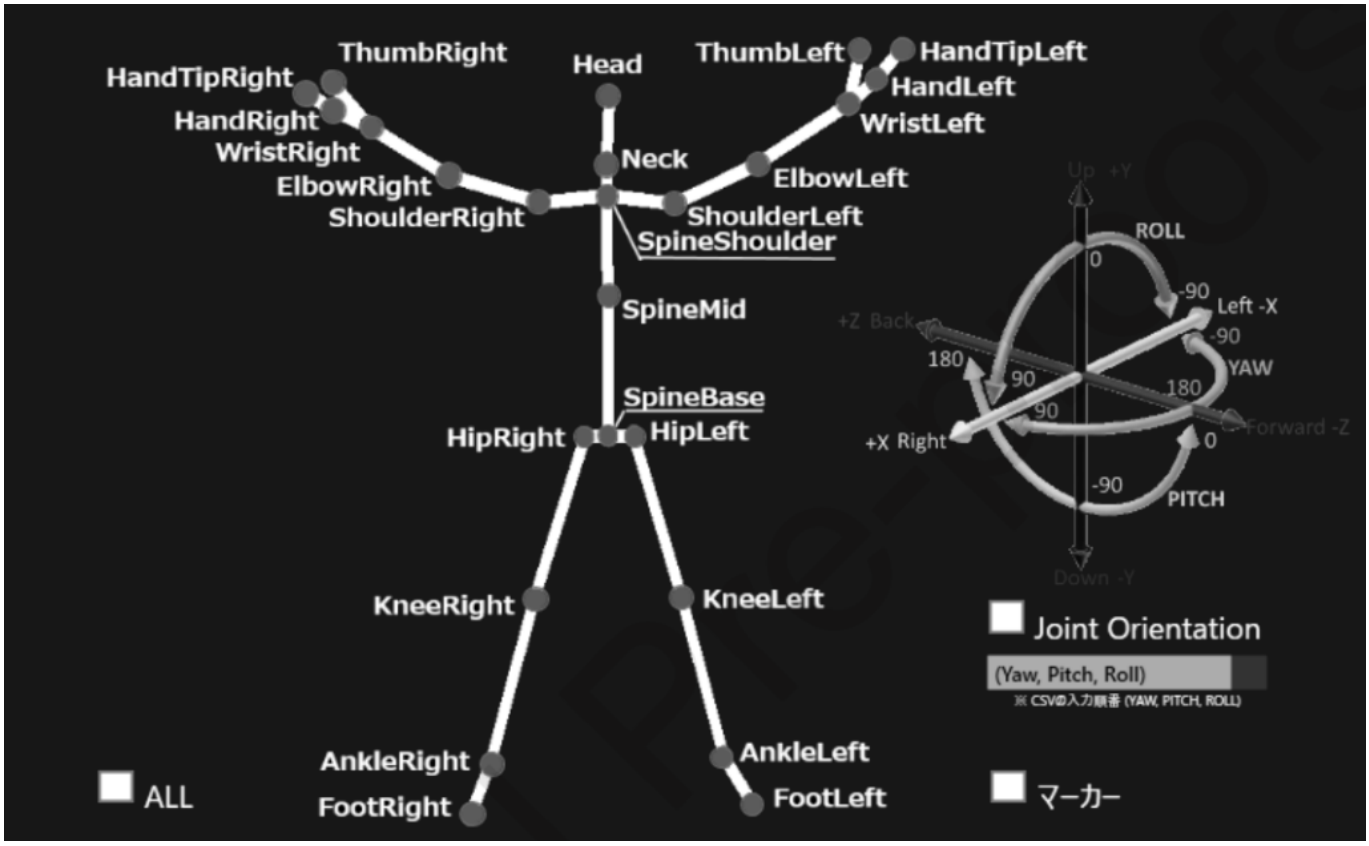

Image Credits: Tanaka, R., Tamura, H., & Kawanishi, H. (2020). Reliability of a markerless motion capture system to measure the trunk, hip and knee angle during walking on a flatland and a treadmill. Journal of Biomechanics, 109929. doi:10.1016/j.jbiomech.2020.109929

Between the two runs, the intraclass correlation (ICC) and the minimum detectable change (MDC) were then calculated. However, the results were not checked against a marker-based system, as the authors did in 2018 in their study “Validity of time series kinematical data as measured by a markerless motion capture system on a flatland for gait assessment”. Here, they found a rather moderate correlation of 20 – 60% between Vicon and Kinect with maximum joint angle deviations of 4.2°.

In the current study it could now be shown that the reliability for knee and hip joint angles is rather low in all parts of the gait, similar to other studies. In contrast, however, a high reproducibility without systematic and small random errors of trunk angle measurements during normal walking, especially in the middle to late stance phase, could be demonstrated. This result can be regarded as the most important finding of the study.

In summary, the scientists concluded that the Kinect v2 can detect kinematic anomalies of the trunk more easily when walking slowly over ground than when walking on a treadmill.

In other words, low-cost markerless systems such as the Kinect v2 can recognize motion curves in such a way that they correspond at least for the most part to the data of established systems. The reproducibility of these results is also partly given. It therefore makes sense for the future to further develop this or similar systems in order to be able to obtain even more accurate data with low costs.

Kinect Azure – Microsoft breaks new ground

As described above, Microsoft initially intended to use the Kinect exclusively for video games. And so the system was developed with only an interface for the Xbox. Microsoft even announced that future versions of the device would be better protected against external influences. Towards the end of 2010, however, the company changed its position on this matter and even explicitly advocated the development of external software. In 2011, the company also released its own Open Kinect Software Development Kit, which was used in the study described above. A year later, a Kinect system developed specifically for Windows was launched, which was offered for $250. The second version appeared two years later, in 2014.

In the meantime, Microsoft has completely abandoned Kinect for video games and the system is no longer available from the manufacturer. Microsoft's Director of Communications, Greg Sullivan, declared 2018: "I think one of the things that is beginning to be understood is that Kinect was never really just the gaming peripheral […]It was always more."

The Kinect Azure has now been on the market since 2019. Here, Microsoft combines an enhanced version of the old Kinect system with its cloud computing service "Azure". Cloud computing is a way of de-localizing computing processes and letting very powerful servers do the work. In relation to Kinect, this is crucial for the integration of complicated computing processes such as artificial intelligence. The new model has been developed exclusively for non-video game based applications and is expected to have very powerful features, especially through cloud computing, which should increase the accuracy of measurements and reduce power consumption. The whole fun costs about 400$, which is still pretty cheap

compared to 3D MoCap systems.

Biomechanical studies on Kinect Azure are not yet available – we are eagerly awaiting the first results!

And by the way: We have no relationship to Microsoft and we don't get any money for this article. This is not an advertisement, but only a list of facts and a hot tip for inexpensive biomechanical analyses

References

Choppin, S., & Wheat, J. (2013). The potential of the Microsoft Kinect in sports analysis and biomechanics. Sports Technology, 6(2), 78–85. doi:10.1080/19346182.2013.819008

Cranz, A. (2018). "Microsoft Kinect Refuses to Die". Gizmodo. Retrieved January 17, 2020

Mentiplay, B.F., Perraton, L.G., Bower, K.J., Pua, Y.H., McGaw, R., Heywood, S., Clark, R.A., 2015. Gait assessment using the Microsoft Xbox One Kinect: Concurrent validity and inter-day reliability of spatiotemporal and kinematic variables. Journal of Biomechanics 48, 2166-2170. https://doi.org/10.1016/j.jbiomech.2015.05.021

Microsoft (2020). https://azure.microsoft.com/de-de/services/kinect-dk/

Pfister, A., West, A.M., Bronner, S., Noah, J.A., 2014. Comparative abilities of Microsoft Kinect and Vicon 3D motion capture for gait analysis. Journal of Medical Engineering & Technology 38, 274-280. https://doi.org/10.3109/03091902.2014.909540

Pöhlmann, S.; Harkness, E.; Taylor, C.; Astley, S. (2016). Evaluation of Kinect 3D Sensor for Healthcare Imaging. *Journal of Medical and Biological Engineering*. 36 (6): 857–870. doi:10.1007/s40846-016-0184-2

Tanaka, R., Takimoto, H., Yamasaki, T., & Higashi, A. (2018). Validity of time series kinematical data as measured by a markerless motion capture system on a flatland for gait assessment. Journal of Biomechanics, 71, 281–285. doi:10.1016/j.jbiomech.2018.01.035

Tanaka, R., Tamura, H., & Kawanishi, H. (2020). Reliability of a markerless motion capture system to measure the trunk, hip and knee angle during walking on a flatland and a treadmill. Journal of Biomechanics, 109929. doi:10.1016/j.jbiomech.2020.109929