Kinect™ and Intel RealSense™ D435 comparison: a preliminary study for motion analysis

Conference Paper · October 2019

DOI: 10.1109/HealthCom46333.2019.9009433

8 authors, including:

Andres Navarro
ICESI University

Beatriz Elena Munoz-Ospina
Fundación Valle Del Lili

Jorge Orozco
Fundación Valle Del Lili

Kinect™ and Intel RealSense™ D435 comparison: a preliminary study for motion analysis

Jeison David Mejia-Trujillo, Yor Jaggy Castaño-Pino, Andrés Navarro, Juan David Arango-Paredes and Domiciano Rincón
I2t Research Team
Universidad Icesi
Cali, Colombia
Email: {jeison.mejia, yor.castano}@correo.icesi.edu.co, {anavarro, jdarango, drincon}@icesi.edu.co

Jaime Valderrama, Beatriz Muñoz and Jorge Luis Orozco
Fundación Valle del Lili
Cali, Colombia
Email: {jaime.valderrama.chaparro, vitrix, jlorozcovelez}@gmail.com

***Abstract*—In this paper, we explore the feasibility to obtain the speed related to a person walking, using a new and unexplored RGB-D camera (Intel RealSense™ D435). For this, we obtain measurements for two devices, the Intel RealSense™and Microsoft Kinect™v2, which has been validated in previous studies. Finally, we compare the results obtained using both devices. This is an important exploration due to the wide variety of applications for this device and the obtained results. The results obtained suggest that this small and inexpensive device can be used to measure some spatiotemporal variables, for different use cases, like eHealth and analysis for high-performance athletes.**

***Index Terms*—RGB-D, Intel, Kinect™, Gait.**

I. Introduction

Gait analysis is an important tool for clinicians and health professionals. This analysis tool allows assessing gait patterns and its changes related to neurological or orthopedic conditions [1]. Some of these changes could be reflected in gait characteristics such as stride time, stride length, stride width, stride variability, and gait speed. Motion-capture systems, such as Vicon Motion Systems or GAITRite, are commonly used to record gait patterns quantitatively and precisely, to help with more complex gait and posture analyses for the physical rehabilitation, sports, video, and gaming industries [2], [3]. Such systems are very costly, however, in terms of the examination time, patient preparation, accessibility, space, and technical expertise required. Recently, medium-complexity motion-capture systems have come onto the market, measuring clinically-useful variables with sufficiently low costs and setup times that they can be used routinely in clinical environments. Microsoft Kinect™ sensor is being tested for use as a primary motion-capture sensor in clinical contexts, and several gait analysis studies have shown that its accuracy is sufficient for PD assessment, with the appropriate software [4-10].

II. Related Work

As mentioned above, RGB-D cameras are useful tools for gait analysis and spatiotemporal variables. These devices guarantee comparable and valid measurements, using fewer resources than conventional labs. Given the high cost and complexity of the labs, new RGB-D cameras have emerged on the market. In [11], the necessary technical specifications of the RGB-D cameras, when they are used for clinical analysis, are listed. Table I gathers some of these specifications, exposed in [11], [12], for the most relevant cameras nowadays. Among the analyzed devices the Kinect™ V1, the Kinect™ V2, and the Intel RealSense™ D435 stand out. Being the two versions of Kinect™ the most used until now, these have been proven to be able to obtain valid, objective and replicable results [13], [14]. Our main interest is to compare the Kinect™ V2 and the Intel RealSense™ D435. The first one is a RGB-D camera, created by Microsoft Corporation in 2014 used originally for user interaction using body motion for the video game console XBox One [15], [16]. However, this RGB-D camera has been used in multiple scenarios and use cases, such as clinical assessment for neurodegenerative diseases, robotics, fall prediction and other fields that involve the analysis of gait variables [17-20].

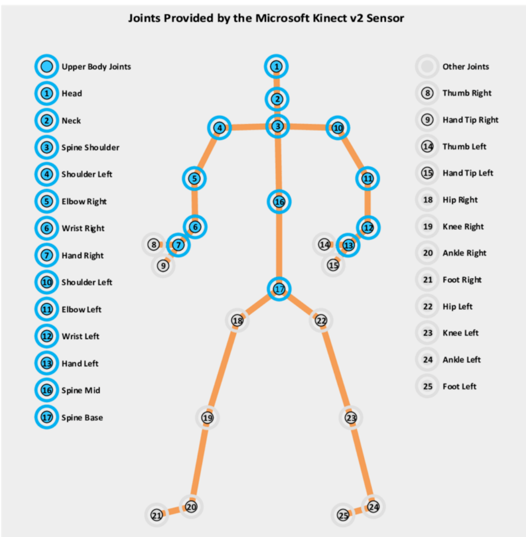
Currently, due to the Microsoft decision to discontinue the development and updates for these devices, new promising options in the market are being explored. The Intel RealSense™ D435 seems to be a good choice given its properties and the market development kits that can be integrated into it for data collection and exploration of spatiotemporal variables [11].

TABLE I
Comparison of devices

Property	Device		
	Kinect™ V1	**Kinect™ V2**	**Intel RealSense™ D435**
Technology	Structured-light	Time-of-flight	Active stereoscopy
DEPTH Range (m)	0.8 - 4.0	0.5 - 4.5	0.2 - 4.5*
Resolution	640 x 480	1920 x 1080	1920 x 1080
Frames Per Second (FPS)	30	30	30
DEPTH Resolution	320 x 240	512 x 424	1280 x 720
Field of View DEPTH	57 x 43	70 x 60	85.2 x 58
Frames Per Second (FPS) DEPTH	30	30	90
Number of Joints	20	25	19

*Despite its capture range is exposed as 10 meters [12], with the Nuitrack SDK we were only able to track skeletons until 4.5 meters.

Recently, Microsoft have announced a new RGB-D camera, the Kinect™ for Azure, which promises a better performance in a small device, with more features than its predecessors [21]. This new Microsoft device is not currently in the market, and one alternative to this device could be the Intel RealSense™ D435. This camera provides good capacities to detect individuals, gestures and facial landmarks [11]. It is also possible integration with the Nuitrack SDK, to allows the users to capture 19 Joints. In Figure 1, we show a comparison between the joints obtained with both devices [22], [23].



(a)

(b)

Fig. 1. The first image (a) show skeletons obtained with the Kinect™ V2 using the official Microsoft SDK. The second image (b) shows the Intel Skeletons obtained with the Nuitrack SDK.

III. Resources and Methods

A. Data

We established a free obstacles corridor, with 1.5m wide and 6m long. Based on the clinical expert criteria, we capture each volunteer at least three times. We attach the Kinect™ V2 camera and Intel D435 to provide an equal field of view for both. These cameras were located at the end of the corridor. Figure 2, shows the cameras and corridor set up.

B. Volunteers Description

This preliminary study involved 6 young individuals between 19 and 25 years old, totally healthy. That is, none presented medical or other conditions that could affect the way they walked in a meaningful way for the analysis.

C. Signal Processing and Speed Calculation

In this exploration, we obtain the time and distance for the closest joint to the center of mass (COM) while walking, in the Intel case was the Waist joint provided by the Nuitrack SDK, and for the Kinect™ was the Hip Center provided by the Kinect™ SDK.

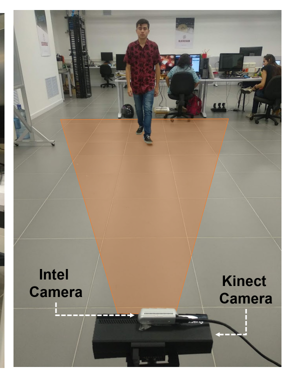
To calculate the speed for each subject, we calculate the time related to the initial and final distance (1) and (2).

$$S = \frac{Distance}{Time} \tag{1}$$

Where:

$$S = \frac{D_2 - D_1}{T_2 - T_1} \tag{2}$$

(a)



(b)

Fig. 2. Cameras (a) and corridor (b) setup.

IV. Results and Discussion

A. Data Differences

In previous studies, we have explored different arm and ankles variables using Kinect™ [24]. When we explored the characteristics of the Intel RealSense™ D435 and the Nuitrack SDK it was found that this camera provides a greater range than the Kinect™ with an average of 0.5m more. Despite this, in the long range and with joints like ankles and wrists, the Intel RealSense™ presents noise data, as seen in Figure

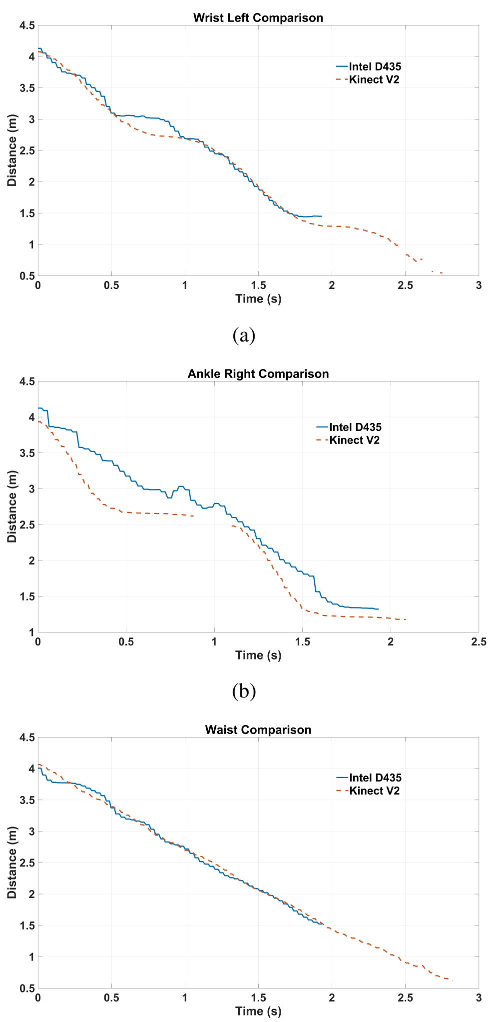
3, which makes difficult to process and generate all the spatiotemporal variables previously obtained with Kinect™.

B. Estimated Speed

In this exploration, we calculated the speed using the Intel RealSense™ and Kinect™ V2 camera, then we compare both results. As we see in table II, the time, distance and speed measured show low differences. Finally, we also perform a Spearman correlation test to evaluate the similarities of the results, from this evaluation a high correlation in each variable was obtained (table III).

C. Limitations

As we mentioned previously, some joints present noise in the captured data, such as ankles and wrists. Despite its capture range is exposed as 10 meters [12], less noised data can be obtained between 0.5 y 4.5 m. Besides, the detection of the subjects is not insured at all times, at a distance of more than 4.5 meters.



(a) (b) (c)

Fig. 3. Main joints comparison: (a) Left Wrist, (b) Right Ankle and (c) Waist.

TABLE II
AVERAGE AND DEVIATION OF SPEEDS

Variables	Intel RealSense™ D435	Kinect™ V2
Time	2.04 (0.18)	2.16 (0.20)
Distance	2.52 (0.03)	2.46 (0.014)
Speed	1.24 (0.11)	1.14 (0.10)

TABLE III
SPEARMAN RHO OF SPEEDS

Variables	Spearman rho
Time	0.90
Distance	0.89
Speed	0.89

V. CONCLUSIONS

In this paper, we explore the feasibility to obtain the speed related to a person walking, using a new and unexplored RGB-D camera (Intel RealSense™ D435). The results obtained suggest that this small and inexpensive device can be used to measure some spatio-temporal variables, especially by using the waist joint. These spatio-temporal variables could be used in different use cases, like eHealth and analysis for high-performance athletes. However, the wrist and ankle joints present noise that may difficult the gait analysis, for which signal processing is needed. In this preliminary result, the Kinect™ seems to be a more reliable RGB-D camera than the Intel RealSense™ D435 to collect skeleton data when comparing the capture range and quality of the signal. In future works, we will evaluate the performance of an array of multiple Intel cameras to obtain more accurate data from arms and ankles, also we will apply some DSP techniques to improve the signal quality.

ACKNOWLEDGMENT

The authors thank the volunteers for their time and participation, and to Colciencias for their continuous support during the strengthening of the neuroengineering research field in the i2t research team.

REFERENCES

[1] L. Donath, O. Faude, E. Lichtenstein, C. Nesch, and A. Mndermann, Validity and reliability of a portable gait analysis system for measuring spatiotemporal gait characteristics: comparison to an instrumented treadmill, Journal of NeuroEngineering and Rehabilitation, vol. 13, no. 1, p. 6, Jan. 2016.
[2] VICON, Motion Capture Systems, VICON. [Online]. Available: https://www.vicon.com.
[3] GAITRite — World Leader in Temporospatial Gait Analysis. [Online]. Available: https://www.gaitrite.com/.
[4] A. P. Rocha, H. Choupina, J. M. Fernandes, M. J. Rosas, R. Vaz, and J. P. Silva Cunha, "Parkinson's disease assessment based on gait analysis using an innovative RGB-D camera system," Conf. Proc. IEEE Eng. Med. Biol. Soc., vol. 2014, pp. 3126–3129, 2014.
[5] Microsoft Corporation. (2017, February). Kinect for Windows Sensor Components and Specifications. Available: http://msdn.microsoft.com/en-us/library/jj131033.aspx.
[6] D. V. Cicchetti and S. A. Sparrow, "Developing criteria for establishing interrater reliability of specific items: applications to assessment of adaptive behavior," Am. J. Ment. Defic., vol. 86, no. 2, pp. 127–137, Sep 1981.

[7] J. D. Arango Paredes, B. Muoz, W. Agredo, Y. Ariza-Arajo, J. L. Orozco, and A. Navarro, ”A reliability assessment software using Kinect to complement the clinical evaluation of Parkinson’s disease,” in 2015 37th Annual International Conference of the IEEE Engineering in Medicine and Biology Society (EMBC), 2015, pp. 6860–6863.

[8] B. Galna, G. Barry, D. Jackson, D. Mhiripiri, P. Olivier, and L. Rochester, ”Accuracy of the Microsoft Kinect sensor for measuring movement in people with Parkinson’s disease,” Gait Posture, vol. 39, no. 4, pp. 1062–1068, Apr 2014.

[9] B. R. Bloem et al., ”Measurement instruments to assess posture, gait, and balance in Parkinson’s disease: Critique and recommendations,” Mov Disord, Mar 2016.

[10] O. Tupa et al., ”Motion tracking and gait feature estimation for recognising Parkinson’s disease using MS Kinect,” Biomed. Eng. Online, vol. 14, no. 1, p. 97, Dec 2015.

[11] F. L. Siena, B. Byrom, P. Watts, and P. Breedon, Utilising the Intel RealSense Camera for Measuring Health Outcomes in Clinical Research, J Med Syst, vol. 42, no. 3, p. 53, Feb. 2018.

[12] S. Giancola, M. Valenti, and R. Sala, State-of-the-Art Devices Comparison, in A Survey on 3D Cameras: Metrological Comparison of Time-of-Flight, Structured-Light and Active Stereoscopy Technologies, S. Giancola, M. Valenti, and R. Sala, Eds. Cham: Springer International Publishing, 2018, pp. 29–39.

[13] J. Latorre, R. Llorens, C. Colomer, and M. Alcaiz, Reliability and comparison of Kinect-based methods for estimating spatiotemporal gait parameters of healthy and post-stroke individuals, Journal of Biomechanics, vol. 72, pp. 268–273, Apr. 2018.

[14] R. A. Clark, K. J. Bower, B. F. Mentiplay, K. Paterson, and Y.-H. Pua, Concurrent validity of the Microsoft Kinect for assessment of spatiotemporal gait variables, Journal of Biomechanics, vol. 46, no. 15, pp. 2722–2725, Oct. 2013.

[15] B. Cubukcu, U. Yzge, R. Zileli, and ahu zileli, A Kinect 2 Based Telerehabilitation Method for Shoulder Rehabilitation Exercises, 2018.

[16] F. Mateo, E. Soria-Olivas, J. J. Carrasco, S. Bonanad, F. Querol, and S. Prez-Alenda, HemoKinect: A Microsoft Kinect V2 Based Exergaming Software to Supervise Physical Exercise of Patients with Hemophilia, Sensors, vol. 18, no. 8, p. 2439, Aug. 2018.

[17] A. P. Rocha, H. Choupina, J. M. Fernandes, M. J. Rosas, R. Vaz, and J. P. S. Cunha, Kinect v2 based system for Parkinsons disease assessment, in 2015 37th Annual International Conference of the IEEE Engineering in Medicine and Biology Society (EMBC), 2015, pp. 1279–1282.

[18] P. Fankhauser, M. Bloesch, D. Rodriguez, R. Kaestner, M. Hutter, and R. Siegwart, Kinect v2 for mobile robot navigation: Evaluation and modeling, in 2015 International Conference on Advanced Robotics (ICAR), 2015, pp. 388–394.

[19] A. N. Staranowicz, C. Ray, and G. Mariottini, Easy-to-use, general, and accurate multi-Kinect calibration and its application to gait monitoring for fall prediction, in 2015 37th Annual International Conference of the IEEE Engineering in Medicine and Biology Society (EMBC), 2015, pp. 4994 – 4998.

[20] B. Mller, W. Ilg, M. A. Giese, and N. Ludolph, Validation of enhanced kinect sensor based motion capturing for gait assessment, PLOS ONE, vol. 12, no. 4, p. e0175813, Apr. 2017.

[21] Azure Kinect DK: desarrollo de modelos de IA — Microsoft Azure. [Online]. Available: https://azure.microsoft.com/es-es/services/kinect-dk/.

[22] N. Camgoz, Human-Computer Interaction Platform for the Hearing Impaired in Healthcare and Finance Applications, 2016.

[23] Nuitrack: Overview. [Online]. Available: http://download.3divi.com/Nuitrack/doc/Overview_page.html.

[24] Y. J. Castao-Pino, A. Navarro, B. Muoz, and J. L. Orozco, Using Wavelets for Gait and Arm Swing Analysis, Wavelet Transform and Complexity, Mar. 2019.