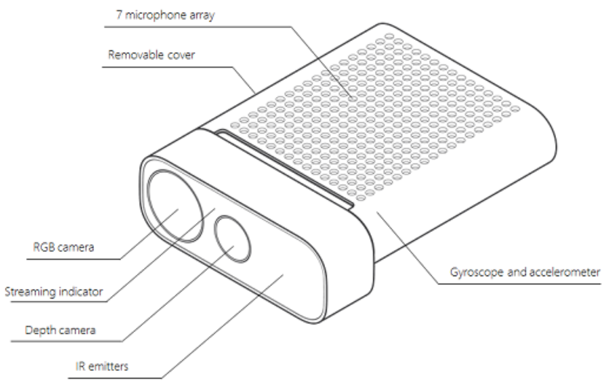
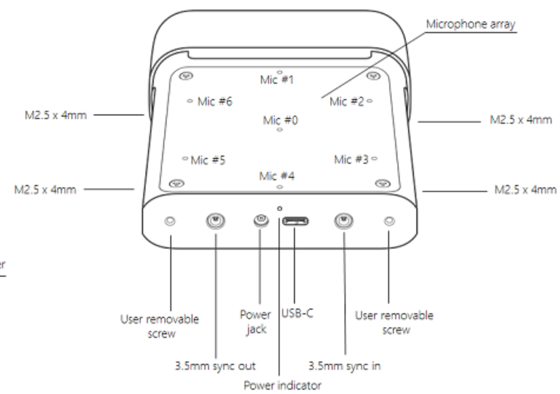
Azure Kinect DK Specifications (Skeletal Tracking)

Which features can be collected and extracted with this device?

Azure Kinect DK is a developer kit with advanced AI sensors that provide sophisticated computer vision and speech models. Kinect contains a depth sensor, spatial microphone array with a video camera (color camera), and orientation sensor as an all in-one small device with multiple modes, options, and software development kits (SDKs).





- Sensor SDK for low-level sensor and device access.
- Body Tracking SDK for tracking bodies in 3D.
  - Provides body segmentation.
  - Contains an anatomically correct skeleton for each partial or full body in FOV.
  - Offers a unique identity for each body.
  - Can track bodies over time.
- Speech Cognitive Services SDK for enabling microphone access and Azure cloud-based speech services.

Depth camera

The **depth camera** supports the modes indicated below:

Mode	Resolution	FoI	FPS	Operating range*	Exposure time
NFOV unbinned	640x576	75°x65°	0, 5, 15, 30	0.5 - 3.86 m	12.8 ms
NFOV 2x2 binned (SW)	320x288	75°x65°	0, 5, 15, 30	0.5 - 5.46 m	12.8 ms
WFOV 2x2 binned	512x512	120°x120°	0, 5, 15, 30	0.25 - 2.88 m	12.8 ms
WFOV unbinned	1024x1024	120°x120°	0, 5, 15	0.25 - 2.21 m	20.3 ms
Passive IR	1024x1024	N/A	0, 5, 15, 30	N/A	1.6 ms

*15% to 95% reflectivity at 850nm, 2.2 μW/cm2/nm, random error std. dev. ≤ 17 mm, typical systematic error < 11 mm + 0.1% of distance without multi-path interference. Depth may be provided outside of the operating range indicated above. It depends on an object's reflectivity.

Color camera

Azure Kinect DK includes an OV12A10 12MP CMOS sensor rolling shutter sensor. The native operating modes are listed below:

RGB Camera Resolution (HxV)	Aspect Ratio	Format Options	Frame Rates (FPS)	Nominal FOV (HxV)(post-processed)
3840x2160	16:9	MJPEG	0, 5, 15, 30	90°x59°
2560x1440	16:9	MJPEG	0, 5, 15, 30	90°x59°
1920x1080	16:9	MJPEG	0, 5, 15, 30	90°x59°
1280x720	16:9	MJPEG/YUY2/NV12	0, 5, 15, 30	90°x59°

4096x3072	4:3	MJPEG	0, 5, 15	90°x74.3°
2048x1536	4:3	MJPEG	0, 5, 15, 30	90°x74.3°

The RGB camera is USB Video class-compatible and can be used without the Sensor SDK. The RGB camera color space: BT.601 full range [0..255]. The MJPEG chroma sub-sampling is 4:2:2.

Acceptable RGB camera manual exposure values:

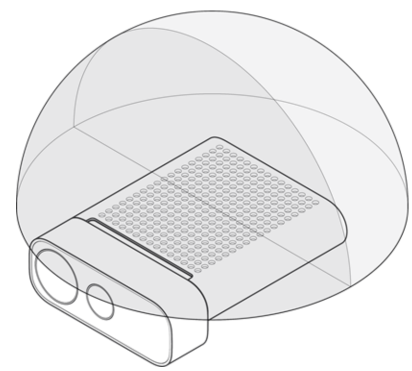
exp	2^exp	50Hz	60Hz
-11	488	500	500
-10	977	1250	1250
-9	1953	2500	2500
-8	3906	10000	8330
-7	7813	20000	16670
-6	15625	30000	33330
-5	31250	40000	41670
-4	62500	50000	50000
-3	125000	60000	66670
-2	250000	80000	83330
-1	500000	100000	100000
0	1000000	120000	116670
1	2000000	130000	133330

Motion sensor (IMU)

The embedded Inertial Measurement Unit (IMU) is an LSM6DSMUS and includes both an accelerometer and a gyroscope. The accelerometer and gyroscope are simultaneously sampled at 1.6 kHz. The samples are reported to the host at a 208 Hz.

Microphone array

Azure Kinect DK embeds a high-quality, seven microphone circular array that identifies as a standard USB audio class 2.0 device. All 7 channels can be accessed. The performance specifications are:



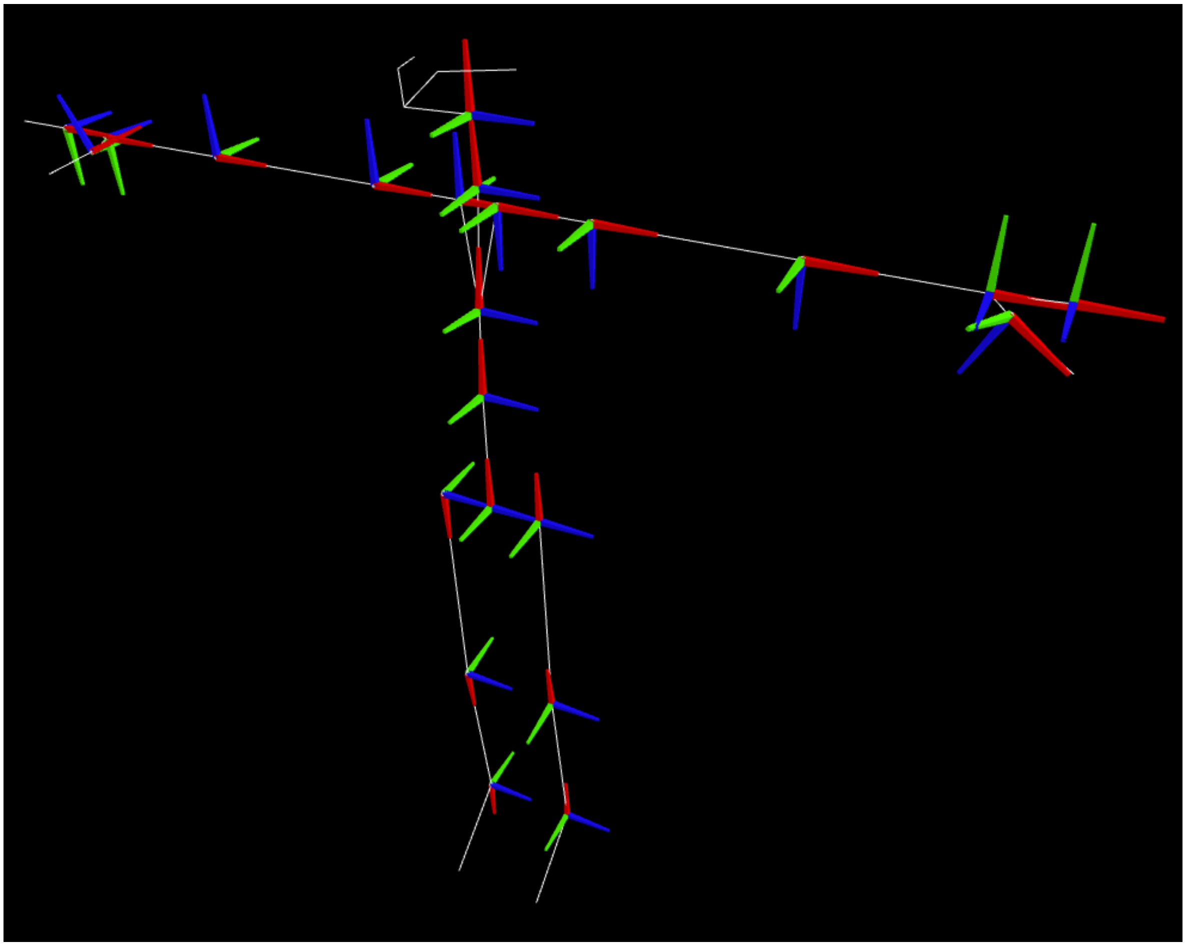
- Sensitivity: -22 dBFS (94 dB SPL, 1 kHz)
- Signal to noise ratio > 65 dB
- Acoustic overload point: 116 dB

Azure Kinect DK hardware specifications:

https://learn.microsoft.com/en-us/azure/Kinect-dk/hardware-specification

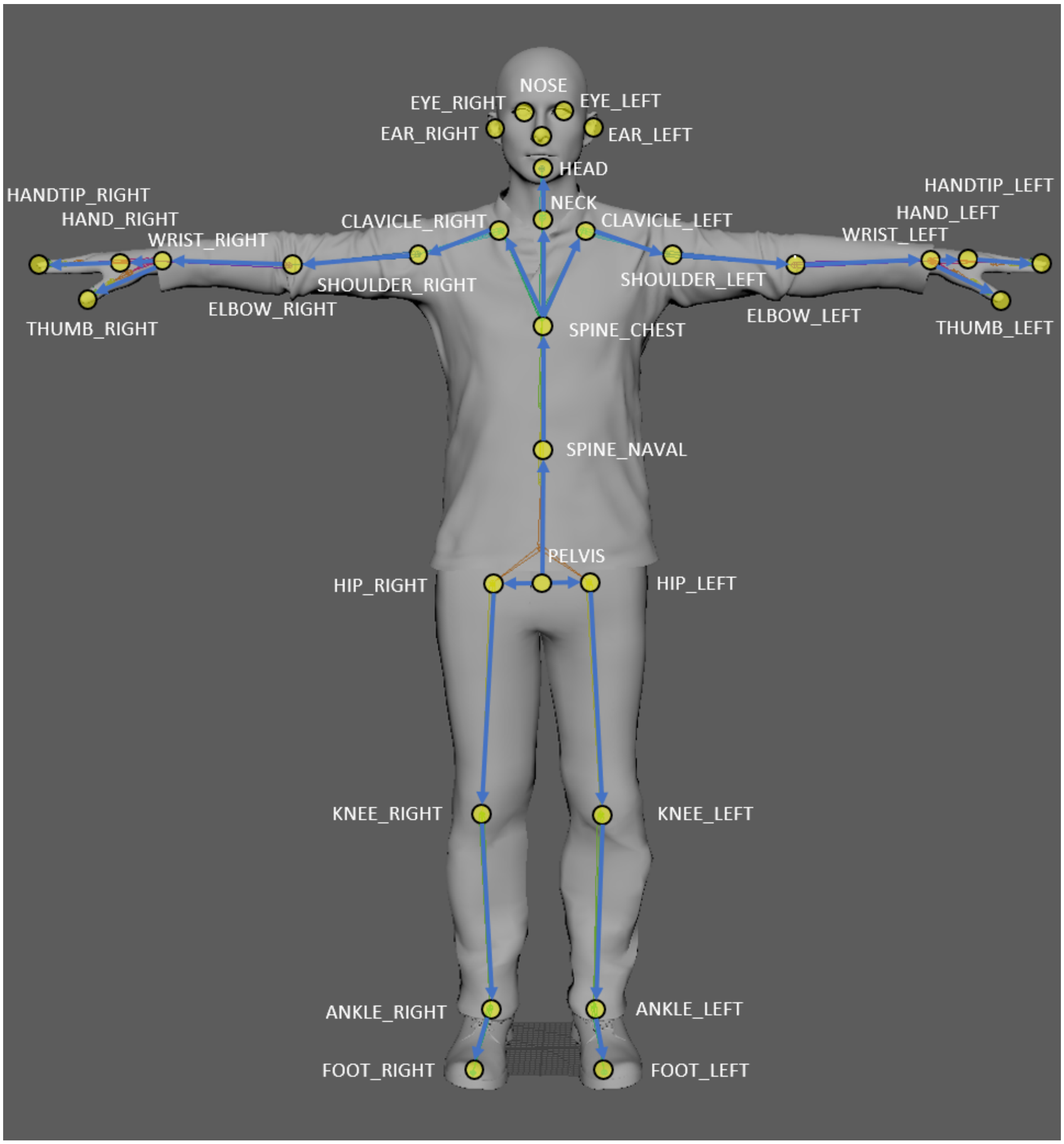
Body tracking joints

The position and orientation of each joint form its own right-handed joint coordinate system. All joint coordinate systems are absolute coordinate systems in the depth camera 3D coordinate system.



| x-axis = red | y-axis = green | z-axis = blue |

A skeleton includes 32 joints with the joint hierarchy flowing from the center of the body to the extremities. Each connection (bone) links the parent joint with a child joint. The figure illustrates the joint locations and connection relative to the human body.


NOSE
EYE_RIGHT
EYE_LEFT
EAR_RIGHT
EAR_LEFT
HEAD
NECK
HANDTIP_RIGHT
HAND_RIGHT
WRIST_RIGHT
CLAVICLE_RIGHT
CLAVICLE_LEFT
HANDTIP_LEFT
HAND_LEFT
WRIST_LEFT
SHOULDER_RIGHT
SHOULDER_LEFT
ELBOW_RIGHT
ELBOW_LEFT
THUMB_RIGHT
THUMB_LEFT
SPINE_CHEST
SPINE_NAVAL
PELVIS
HIP_RIGHT
HIP_LEFT
KNEE_RIGHT
KNEE_LEFT
ANKLE_RIGHT
ANKLE_LEFT
FOOT_RIGHT
FOOT_LEFT

The following table enumerates the standard joint connections.

Index	Joint name	Parent joint
0	PELVIS	-
1	SPINE_NAVAL	PELVIS
2	SPINE_CHEST	SPINE_NAVAL
3	NECK	SPINE_CHEST
4	CLAVICLE_LEFT	SPINE_CHEST
5	SHOULDER_LEFT	CLAVICLE_LEFT
6	ELBOW_LEFT	SHOULDER_LEFT
7	WRIST_LEFT	ELBOW_LEFT
8	HAND_LEFT	WRIST_LEFT
9	HANDTIP_LEFT	HAND_LEFT
10	THUMB_LEFT	WRIST_LEFT
11	CLAVICLE_RIGHT	SPINE_CHEST

12	SHOULDER_RIGHT	CLAVICLE_RIGHT
13	ELBOW_RIGHT	SHOULDER_RIGHT
14	WRIST_RIGHT	ELBOW_RIGHT
15	HAND_RIGHT	WRIST_RIGHT
16	HANDTIP_RIGHT	HAND_RIGHT
17	THUMB_RIGHT	WRIST_RIGHT
18	HIP_LEFT	PELVIS
19	KNEE_LEFT	HIP_LEFT
20	ANKLE_LEFT	KNEE_LEFT
21	FOOT_LEFT	ANKLE_LEFT
22	HIP_RIGHT	PELVIS
23	KNEE_RIGHT	HIP_RIGHT
24	ANKLE_RIGHT	KNEE_RIGHT
25	FOOT_RIGHT	ANKLE_RIGHT

26	HEAD	NECK
27	NOSE	HEAD
28	EYE_LEFT	HEAD
29	EAR_LEFT	HEAD
30	EYE_RIGHT	HEAD
31	EAR_RIGHT	HEAD

References:

- https://learn.microsoft.com/en-us/azure/kinect-dk/about-azure-kinect-dk
- https://learn.microsoft.com/es-es/azure/kinect-dk/depth-camera
- https://learn.microsoft.com/en-us/azure/kinect-dk/coordinate-systems
- https://learn.microsoft.com/en-us/azure/Kinect-dk/hardware-specification

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How are such features related to Skeletal tracking?

Skeletal tracking is the process of detecting and tracking the human skeleton and body joints in real-time. Skeletal tracking is an important application of Azure Kinect DK, as it allows for a variety of applications.

The depth map captured provides the 3D spatial information required to accurately track the human body in real-time. The depth map is used to create a 3D point cloud of the environment, which is then analyzed to detect and track the human body.

Once the body is detected, Azure Kinect DK can track the movement of the body joints in real-time, using algorithms that are based on machine learning and computer vision techniques. The tracked body joints can be used to create a skeletal model of the human body.

Some videos about it

- A Short Introduction to Motion Capture and Showcase of Different Systems
- Developing with Kinect for Azure - Understanding the human body by Andrea…

References:

- Tölgyessy, M., Dekan, M., & Chovanec, Ľ. (2021). Skeleton tracking accuracy and precision evaluation of Kinect V1, Kinect V2, and the Azure Kinect. *Applied Sciences (Basel, Switzerland)*, *11*(12), 5756. https://doi.org/10.3390/app11125756.
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- Clark, R. A., Mentiplay, B. F., Hough, E., & Pua, Y. H. (2019). Three-dimensional cameras and skeleton pose tracking for physical function assessment: A review of uses, validity, current developments and Kinect alternatives. *Gait & Posture*, *68*, 193–200. https://doi.org/10.1016/j.gaitpost.2018.11.029.
- Ripic, Z., Kuenze, C., Andersen, M. S., Theodorakos, I., Signorile, J., & Eltoukhy, M. (2022). Ground reaction force and joint moment estimation during gait using an Azure Kinect-driven musculoskeletal modeling approach. *Gait & Posture*, *95*, 49–55. https://doi.org/10.1016/j.gaitpost.2022.04.005.

How could we relate such features to learning?

There are multiple studies in the literature which relate skeletal tracking and RGB camera, from devices such as the Azure Kinect, to different learning activities and environments.

Such studies seek to analyze skeletal tracking and facial tracking to gain a deeper understanding on:

- Kinesthetic Learning
- Multimodal sensing
- Facial recognition.

References:

- Ocampo, H., Silva, G., & Salinas, P. (2015). *Kinect TEAM: Kinesthetic Learning Applied to Mathematics Using Kinect* (Ramirez Flores P.G., Martin Gutierrez J., Mendivil E.G., & Ginters E., Eds.; Vol. 75). Elsevier B.V. 10.1016/j.procs.2015.12.234.

- Lin, L., & Shi, L. (2022). *Research on student classroom attention recognition based on multimodality* (Lu Y. & Cheng C., Eds.; Vol. 12506). SPIE.

- Fakhar, S., Baber, J., Bazai, S. U., Marjan, S., Jasinski, M., Jasinska, E., Chaudhry, M. U., Leonowicz, Z., & Hussain, S. (2022). Smart classroom monitoring using novel real-time facial expression recognition system. *Applied Sciences (Basel, Switzerland)*, *12*(23), 12134. https://doi.org/10.3390/app122312134.