Kinect: From Entertainment to Scientific Research on Virtual Movement

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Abstract. A few years ago the world has experienced the birth of a new approach to the game controlling. Although the classic mouse & keyboard configuration will not be beaten so easily, the new motion sensing controllers bring the gaming to a whole another level. The purpose of this publication is to bring a general information about Kinect, its history and future as well as its bright and dark sides.

Keywords
Kinect, motion sensors, RGB camera, depth scanning, Xbox, Project Natal.

1. Introduction

As Luo and Yang state, Kinect is a line of motion sensing input devices by Microsoft for Xbox 360 and Xbox One video game consoles and Windows PCs [1]. It utilizes device similar to a web camera which is designed in such a way that its users are able to control this device through various gestures or even speech.

After its release, the first three months were extremely successful for Xbox 360. Zhang states that in that period Kinect’s sales climbed up to more than 10 million [2] which granted Kinect a record for the Fastest-Selling Consumer Electronics Device in the Guinness World Records.

The software for Kinect was developed by Rare, owned by Microsoft. The hardware consists of three main parts [1]:

- RGB camera,
- Depth sensor,
- Multi-array microphone.

The camera with the sensor were produced by an Israeli developer at PrimeSense. They both provide Kinect with the ability to interpret gestures in three dimensions. This is possible because of an infrared projector, camera and a special microchip, which brings the movement tracking into the game. Moreover, it also includes Light Coding, a 3D scanner which allows image-based 3D reconstruction. Altogether, they enable their users to achieve expected results.

2. Kinect V1

As Clayman remembers, Kinect was presented for the first time in June 2009 at "Electronic Entertainment Expo" under the title "Project Natal" [3]. Microsoft came up with the name Kinect a year later.

Kinect (Fig. 1) is compatible with Xbox game consoles so it was not a surprise that the first presentations regarding its utilization were mainly focused on games.

![Typical Kinect V1 graphics](image)

Fig. 1. Typical Kinect V1 graphics

Based on Sector Portal [4], the opening variety of games was focused mainly at nonplayers, who Microsoft wanted to lure to Xbox 360. So the audience, which had not played so far, because the controller was too difficult for them. Thanks to Kinect they just step in front of the TV and they can start playing without any learning. They just control some character on the screen with their body (Fig. 2) and do whatever they want their character to do so. In the beginning, the games were as simple as sports, minigames, dancing or physical exercises. The first bigger game with a story was the Harry Potter game.

As you can read at Microsoft’s News [5], in the beginning of the year 2011 a non-commercial set of tools was published (SDK – Software Development Kit). It was supposed to bring the increasing community of scientists, developers and others to Kinect for Windows to experience human motion tracking, depth sensing or voice and object recognition.

As Zhang wrote, Microsoft calls this the Kinect Effect [2]. The new Kinect technology, launched on 4 November...
2010, made such a boom, that just a month later there were already nine pages containing brief descriptions of approximately 90 projects, and the number of projects posted on KinectHacks.net has grown steadily. There were 24 pages on 10 February 2011, 55 pages on 2 August 2011, 63 pages on 12 January 2012, and 65 pages on 18 February.

![Fig. 2. Example of Kinect remote control](image)

A former news site and discussion community KinectHacks.net commented on Kinect’s success: *Every few hours new applications are emerging for the Kinect and creating new phenomenon that is nothing short of revolutionary* [2].

The first scientific contribution regarding Kinect [6] described the way of how different engineers broke into its functionality or gained control over its motors and sensors.

![Fig. 3. Kinect skeletal tracking](image)

As it continues in [2], skeletal tracking is one of the innovations Kinect has brought to market. The demands on such systems are relatively high. Not only they must fit the way of how they are used, they must recognise a person from any distance or any angle. It has to take into account the shape of the person, size, hair and clothing as well as the environment in the household such as lights, furniture or pets.

Kinect observes human body as a number of joints representing body parts such as head, neck, shoulders and arms (Fig. 3). Every joint is defined by its 3D coordinates. Kinect is scanning all the joints at once in order to provide fluent interactivity which results in a good gaming experience. Microsoft has chosen the way of recognition per-pixel for different body parts, rather than observing the whole pose in 3D at once.

Microsoft is also the developer of a new DMF (Deformable Model Fitting) algorithm for 3D face recognition, which uses Kinect to regularize the mimic with the maximal probability.

![Fig. 4. Example of face sensing](image)

Microsoft Avatar Kinect is using this technology, so one may do whatever he wants to in front of the Kinect and his avatar on the screen will imitate everything he carries out from talking or smiling to voice expressions. Using Kinect one can connect with other friends online, within a chosen environment they can meet together in order to perform activities they could do in a real life even if they are not able to meet physically. This way, one may actually see his friends’ reactions in a real time.

3. Kinect V2

As stated in [7], the fact that newer versions are produced periodically indicates that the Kinect as well as SDK development still proceeds. Today, the most actual Kinect is of version 2 (V2), also called Kinect for Xbox One (Fig. 5).

![Fig. 5. Example of face sensing](image)

According to Dado [8], with the arrival of Xbox One in 2014 the motion sensor started to play a lot more important role. It not only serves for playing games, but one may control the entire Xbox with it. By just saying *Xbox one* the console turns on. Same happens with turning off. Kinect 2 got other improvements as well, concerning the speed of the moves. Thus, it recognises particular moves faster, making the response shorter, of course. Moreover, now it can sense up to six users at once. It can also record one’s heart-rhythm.
As for the Xbox One games, there is no shortage of them. Right after the launch there were many titles available like Battlefield 4, FIFA 14, Call of Duty: Ghosts, Exclusive Ryse: Son of Rome and Dead Rising 3. Forza Motorsport 5 is worth mentioning as well, since it is probably the best example of what Xbox One is capable of. There are a lot of applications too, e.g. YouTube, Skype, Xbox Video, Blu-ray Player, U-play or Twitch.

4. Scientific Contributions by Kinect

First scientific publications mentioning Kinect analyze its effects [9], [10], but mainly they describe its potential applications in augmented reality [11], [12] or they analyze human motion in a specific environment [13], [14]. These publications prove Kinect has had a great potential since its very beginning not only in the gaming area but also in the field of virtual reality, environment analysis or various sensor fusions based on the newest technologies.

Other frequent problematics discussed publications have an evaluation character, regarding several comparisons between various sensors, including Kinect [15].

In [16] the authors performed an experiment based on a set of 13 measurements describing selected problems in gesticulation recognition. It nicely categorises gestures by visible representation into static (poses) and dynamic gestures. By interpretation it divides the gestures on emblems (thumb up), illustrators (pointing), regulators (hand raising at discussion), affect displays (facial expressions in combination with gestures), adaptors (adjusting glasses) etc.

As Henry et al. state in [17], Kinect uses RGB-D camera (Fig. 6) which captures both visual (RGB) and depth (D) information. There have been custom-build devices based on this system years ago, but just now after Kinect’s release it became popular in research areas. Now it is used mainly in gaming and entertainment, but hopefully it will be used more frequently in other areas as well.

The publication [18] of Khoshelham et al. discusses more about depth sensing. Depth and colour images are captured at a framerate of up to 30 fps. About 300,000 pixels in every frame provide a complete point cloud of an indoor environment in a real time.

Numerous publications point out that Kinect is not a flawless depth sensor [19]. There are noises (shadow-like errors) produced because of different reasons like objects too close or too far from Kinect, mirror-like surfaces or in contrast the surfaces that absorb the light. Another problem occurs when multiple Kinects are used together. Their infrared sensors tend to intersect causing more noise.

Kinect has already found its utilization in health-care. There was a study [20] which used Microsoft’s Kinect motion sensor to develop an intelligent rehabilitation system. After many conversations with some therapists they realized that people with different physical disabilities tend to lack enthusiasm for physical exercise prescribed to them by doctors. This is why they came up with an idea of using Kinect through different enjoyable games and activities to help these people move more. The result was that people started to exercise more and to be more motivated about recovery.

Another great utilization is Adora, Doctor’s Operational Research Assistant created by Slovenian students [21]. The assistant is controlled by voice and hand gestures what enables surgeons to access patient data in a computer touchless, i.e. no additional device has to be present within the sterile operating field (Fig. 7). Such a system saves a lot of time, previously spent by leaving surgery room, working on a computer but mainly spent by hygienic process when entering the surgery room back again. The project was successful in 2013 during world finale of Microsoft Imagine Cup [22].
5. Conclusion

The purpose of this publication was to analyze Kinect by Microsoft, starting from its history, through current scientific topics to its potentials in the future. We have skimmed through the development of Kinect from the beginning to the present. Microsoft has improved it since the launch of the Kinect V1 in 2009, so it is no more yet another gaming console. Kinect has a huge influence on the world whether we take games into account or science.

Many scientific contributions have been published regarding Kinect and we are sure there will be more of them. Kinect V2 took the depth mapping or motion sensing to an entirely other level. We believe new version of Kinect will be presented soon. The public is already curious whether to expect an improvement in depth sensing, useful e.g. in an environment modeling or motion sensing, so it will soon recognize well even the fingers or mimic features of the face.

It is probable robotics will depend on Kinect-like sensors in the future. Kinect-based online wardrobe [23] is already under development. The aim is to try clothing virtually outside stone shops. It is also very probable that Kinect-like technologies will be used in education as well.

Streaming is a well-known technology. It is common that one may watch a lecture from the other side of the world. However, these new technologies can help to be actually in the lecture room, e.g. lifting a hand to ask a question. Holograms from Star Trek do not look so sci-fi anymore. Curious about the future? We are too. Let us wait together!

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References
