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# Metrological comparison between Kinect I and Kinect II sensors

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ABSTRACT

This work shows a metrological comparison between Kinect I and Kinect II laser scanners. The comparison is made using a standard artefact based on 5 spheres and 7 cubes. Accuracy and precision tests are done for different ranges and changing the inclination angle between each sensor and the artefact. Results at 1 m range show similar precision in both cases with values between 2 mm and 6 mm. However, at 2 m range values of Kinect I increase up to 12 mm in some cases, while Kinect II keeps all results below 8 mm. Accuracy is also better for Kinect II at 1 m and 2 m range, with values always lower than −5 mm. Accuracy for Kinect I reaches −12 mm at 1 m range and −25 mm at 2 m range. Precision study shows a decrease of precision with range according a second order polynomial equation for Kinect I, while Kinect II shows a much more stable data. Measurement range of Kinect II is limited to 4 m, while Kinect I can obtain data up to 6 m.


## 1. Introduction

3D modelling of the environment is something that is becoming more widespread with applicability in fields such as civil engineering [1], quality control in industry [2], robotics [3], cultural heritage [4], mining [5], or the entertainment industry [6]. In recent years, laser scanners have become widely used systems for the performance of 3D models of the environment. Depending on the type of application parameters such as range, accuracy or measurement rate are fundamental for choosing one laser scanning system over the other.

Applications in civil engineering, mining, and environmental science (e.g. surveying of a riverbank, a quarry, or a road slope) require long range (hundreds of meters) with accuracies typically around 1 cm. Architecture and cultural heritage (facades of historical buildings) require intermediate range of some tens of meters with accuracies better than 5 mm. Quality control in automotive or aerospace industry requires short range (sometimes lower than 1 m), high accuracies (0.1 mm or even better) and high measurement rate. Most of the systems used for quality control are embedded in production lines, therefore there is a need for synchronization with the manufacturing of the parts. Autonomous robots use laser scanners to map the environment, obstacle detection, and navigation-aid. They typically need medium range (30 m maximum) and low accuracy (between 3 cm and 5 cm) systems. However, since being part of a real-time control system, they need high scanning rate. Entertainment industry has more recently contributed to the development of such systems well-known as gaming sensors. They seek low-cost systems with low–intermediate ranges (between 1 m and 5 m; to work in a domestic room) and high measurement rate (to map quickly the player's movements and transmit them to the videogame). In addition, although the accuracy begins being low, the greater demands of the players, who

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**Fig. 1.** Kinect I laser scanner with highlighting of IR illuminator, RGB camera and IR sensor (top), and Kinect II laser scanner with RGB camera, IR sensor and IR illuminator (bottom).

want the response of the avatars accurately synchronized with their movements, is pushing the improvement of accuracy of the laser scanners.

Asus and Microsoft were two of the most popular laser scanning systems for the entertainment industry with the Xtion and Kinect systems. Kinect sold more than 24 million systems whole over the world. Both systems consist of low-cost triangulation laser scanners that have become very popular during the last couple of years. Due to the great community of potential developers working with these systems, many new applications have been developed that extend the potential of the systems to other fields different to entertainment. Some examples are indoor robotics, face recognition, virtual learning, and forensic science [7–12].

Recently, Microsoft has released Kinect II. It is based on a time-of-flight technology instead of triangulation-based former scanner. According the technical specifications, Kinect II improves Kinect I with higher camera resolution, depth resolution and frame rate [13]. However, there are not official data about the metrological characteristics of the depth measurements (i.e. accuracy and precision). These data could be very valuable for users to determine the real possibilities of the systems in many applications.

The aim of this work is to use a previously calibrated standard artefact to perform a metrological comparison between Kinect I and Kinect II sensors. Section 2 of the manuscript depicts the materials and methods used for the comparison and Section 3 the results and discussion. Conclusions are exhibited in Section 4.

## 2. Materials and methods

### *2.1. Laser scanners Kinect I and Kinect II*

Main differences between Kinect I and Kinect II sensors (Fig. 1) are described in Table 1 [13]. The ranging technology of the Kinect II sensor uses a novel image system that indirectly measures the time it takes for laser pulses to travel from the IR illuminator to the image sensor after returning from the target surface. This technology divides a pixel in a half and then they are turned on or off alternatively (180° out of phase between them). The light source is pulsed in phase with the first pixel of each couple. The returned light is absorbed by the half pixel turned on and rejected by the half pixel turned off. That means that when the distance between the system and the target is increased the total amount of light absorbed by the first pixel will decrease slightly, while the second pixel increase slightly. When the target is out of range, the light photons arrive later than second halves pixels are turned on. The photons are detected by first pixels, although in another cycle.