Design of an accurate and low cost 4D foot scanner

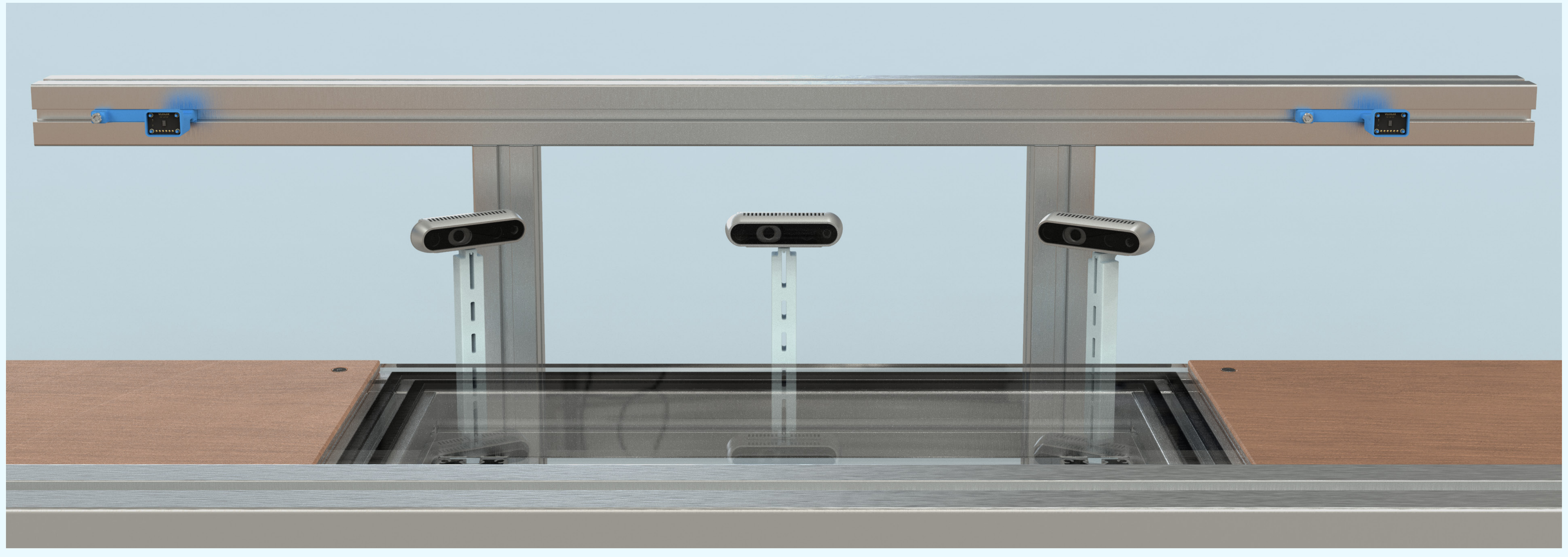
Podiatrists focus on the treatment of physical conditions in the lower regions of the human body, which are often related to foot conditions. Personalized footwear solutions (e.g. orthotics) are widely used to relieve a patient of such conditions, which are primarily designed based on static 3D scanning data of the foot. With additional input of motion analyses and professional experience, a podiatrist can adjust the design of an orthotic to fit the patient.

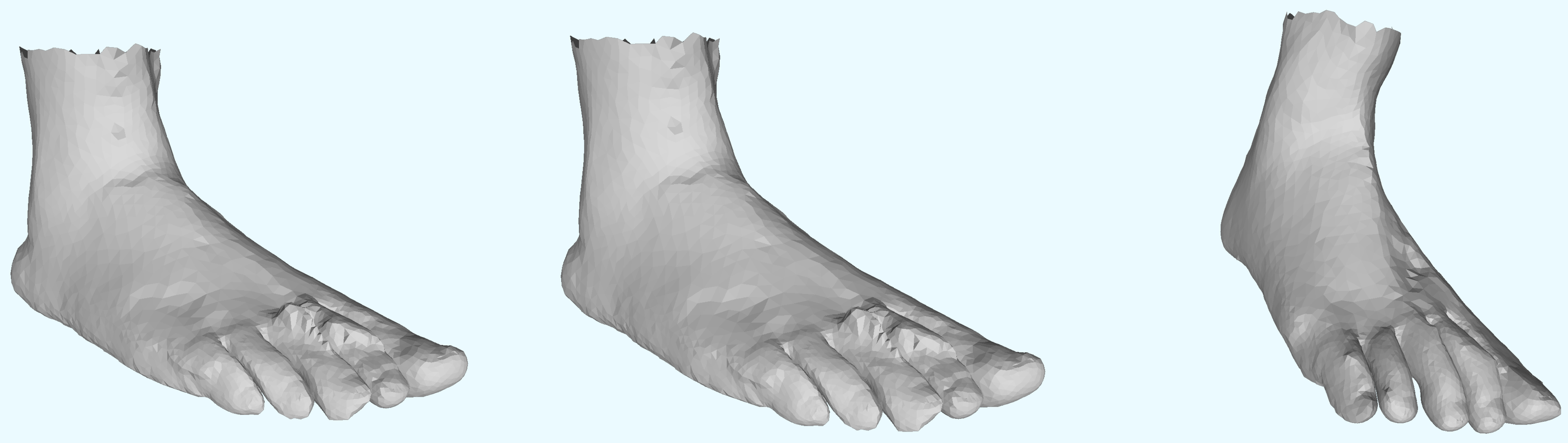
However, the change in foot measurements during different phases of the gait cycle are not accounted for in the design of these personalized solutions, which could vary up to 8 mm. With 4D foot scanning (dynamic 3D scanning), podiatrists will be able to observe and acquire data of the dynamic morphology of a foot during the gait cycle. This should allow the design and development of truly personalized orthotics that are able to support a patient during the entire gait cycle.

To support this vision, **a proof of concept of a 4D foot scanner has been developed**. The presented proof of concept iterates over a previously built 4D foot scanner (Vidmar, 2020). The proof of concept includes: an **optimized embodiment for improved scanning quality and scanning consistency**, a **trigger system to improve the human-computer interaction of the scanner**, and a **scalable camera configuration for up to 9 cameras**.

Hardware performance evaluation

The hardware performance of the scanner in combination with the newly designed data acquisition pipeline has been evaluated in terms of acquisition consistency, speed, and memory usage. The outcome is that the scanner is able to manage dynamic data acquisition with a camera configuration of 9. Also, for a camera configuration of 7, the scanner shows a linear trend in memory consumption, acquired frames, and acquisition speeds, which suggests that performance of the scanner is predictable and constant for this configuration. More elaborate analyses should give better insights into the long time performance of the scanner for different camera configurations.

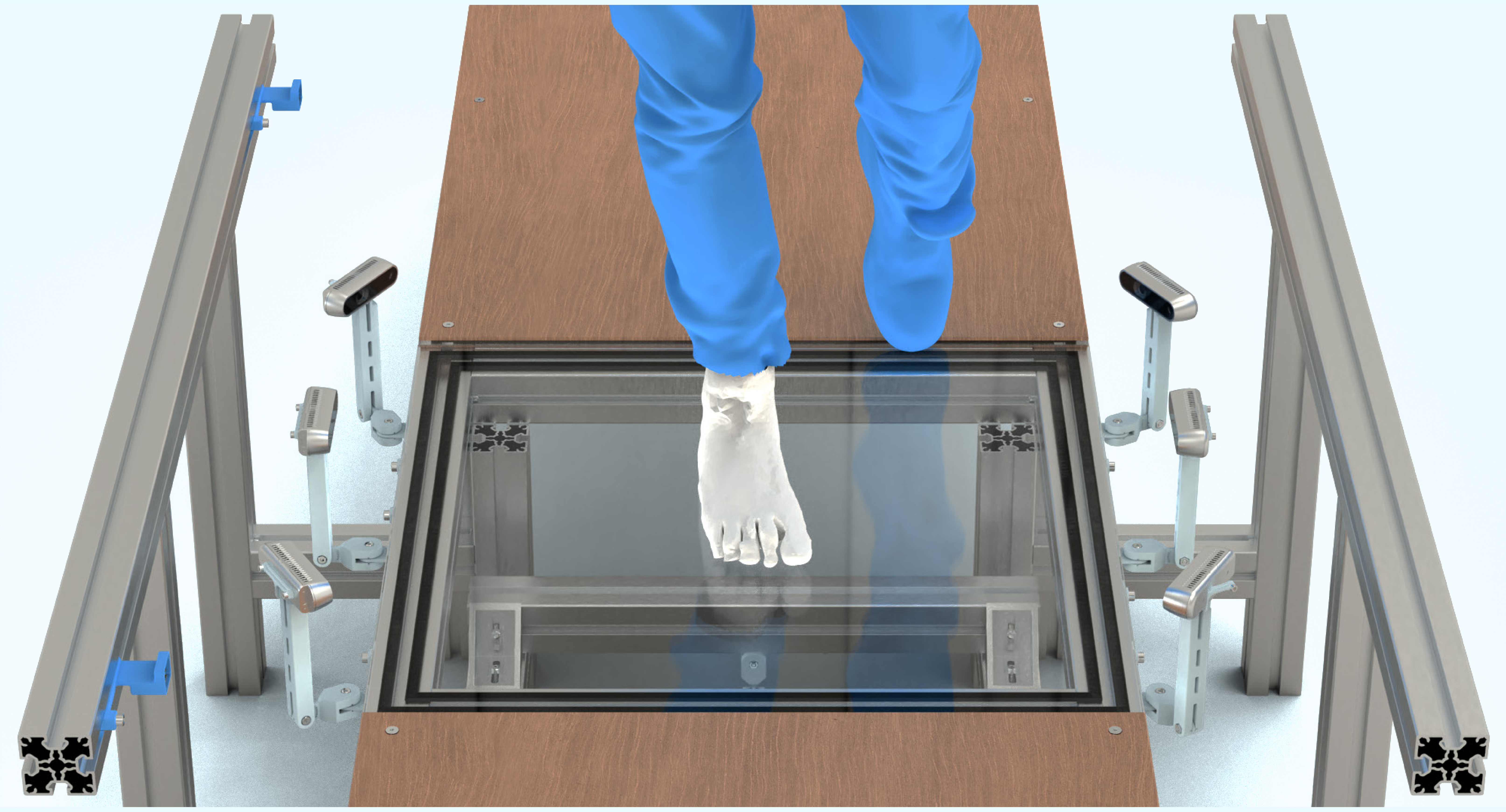




3D reconstructed 4D foot scans in different stances of the gait cycle (l.t.r.: foot-flat, midstance, heel-off).

3D foot reconstruction from foot dynamic scans

The evaluation of the quality of both static and dynamic scanning data has been done with the implementation of nonrigid ICP. The accuracy of the scanner showed a minimal accuracy error of 2.274 mm. Compared with international 3D scanning standards (minimum accuracy error of 2 mm), the performance of the scanner is considered as a desirable outcome for this graduation project.



Felix Kwa
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Committee: Dr. Y. (Wolf) Song
Dr. T. Huysmans

Faculty of Industrial Design Engineering

TU Delft
DELFT UNIVERSITY OF TECHNOLOGY