Author's response to reviews

Title: Determination of the human spine curve based on laser triangulation

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Author's response to reviews: see over
First revision, dated October 8th, 2014:

Dear Sirs,

thank you very much for taking your time to revise our manuscript »Determination of the human spine curve based on laser triangulation« (MS: 1674272075139290). We have carefully read constructive comments of both reviewers and prepared the following response. If not explicitly stated, equations, figures, and reference numbers in our response are related to our originally submitted manuscript.

Reviewer 1:

Comment 1:
“Authors said that measurement took approximately 10 seconds at 700 mm of the longitudinal translation along the back. In this case, how they prevent during this period the patient’s spontaneous self-movements, which can be more significant than declared accuracy of 0.1 mm?”

Our response:
First of all, we would like to clarify the meaning of the declared accuracy of single point measurement of the presented 3D laser profilometer. The declared accuracy of single point measurement, which was 0.1 mm, represented the standard deviation of differences between the real and measured value for all three spatial coordinates X, Y and Z. It was achieved by the calibration of the laser measurement system, which was made by scanning the reference static surface that has a known, mathematically defined surface. Of course we were aware of the fact, that during the scanning of patients, there are presented spontaneous self-movements. That is why, in our manuscript on the page 5, we wrote the measurement protocol, which was the same for every patient and was proposed with patient’s self-movements in our mind: “The patients were measured in the upright standing posture, leaning against foam attached to the wall with their arms placed by the body. Each patient held their breath during each measurement, which lasted approximately 10 seconds.” We would like to point out, that the declared accuracy of 0.1 mm was not the declared accuracy of scanning the patient’s back surface, which in fact was quasi static surface. That is why, we assessed the intra-operator repeatability, which is proposed on page 8. We made 20 successive measurements of the same person and assessed the repeatability of the upright human posture. Table 2 on page 17 presents the results. We can see that in the frontal and sagittal plane the repeatability of the upright human posture is around 2 mm and 4 mm, respectively.

Comment 2:
“Not defined exactly the novelty of the presented method over other introduced in [4-14].”

Our response:
The main novelty of the presented method over introduced [4-14] is automatic determination of spatial spine curve based on the measured 3D shape of the back, which is later validated by determination of the so called manual spine curve, that was defined by palpation and marking the thoracic and lumbar spinous processes. Based on the review of the literature, presented in the background of our manuscript, we have not found any reported studies using the laser triangulation imaging method to determine the spatial spine curve and validate the method by spinous process palpation instead of using a harmful and invasive radiographic imaging methods.
**Reviewer 2**

**Comment 1:**
"This article is well written, the study is conducted fairly, the method is rigorous, but the subject is not innovative, studies on similar systems and techniques that have already been conducted."

**Our response:**
The main novelty of the presented method over introduced [4-14] is automatic determination of spatial spine curve based on the measured 3D shape of the back, which is later validated by determination of the so called manual spine curve, that was defined by palpation and marking the thoracic and lumbar spinous processes. Based on the review of the literature, presented in the background of our manuscript, we have not found any reported studies using the laser triangulation imaging method to determine the spatial spine curve and validate the method by spinous process palpation instead of using a harmful and invasive radiographic imaging method.

**Comment 2:**
"The authors emphasize the spatial character of scoliosis (3D) in the introduction, then the results focus on the sagittal and frontal views (2D), it would have taken a closer look at the new standards on the 3D models in the field scoliosis."

**Our response:**
Main objectives of the presented research were firstly developing a method for automatic determination of spatial spine curve based on the measured 3D shape of the back, secondly validating the presented method by determination of the so called manual spine curve, which was performed by palpation and marking spinous processes and thirdly to assess the inter/intra-operator repeatability. In order to accomplish the presented objectives, we developed a method that determines a so called automatic spatial (3D) spine curve that is presented on page 7 and in figure 5. This determination is based only on the 3D depth image of the back. Novelty of the presented research is the validation of the presented method. It was made using the comparison of the manual and automatic curves. Since physicians find the most interesting spine curves in the frontal and sagittal planes (2D), our results focused exclusively on the frontal and sagittal views of the automatic and manual curves. In case of deeper research on spatial characteristics of scoliosis, we would present a 3D view of the determined spine curve.

**Comment 3:**
"Also the only argument of the dose is to discuss again with the introduction of new systems such as EOS and its very low dose."

**Our response:**
EOS is a low-dose X-ray imaging system, whose estimated effective dose for an adult is about 290 µSv in case of full spine examination [i]. The measurement for simultaneously acquisition of both posterior-anterior and lateral images takes about 20 seconds. However, although the estimated effective dose in case of using EOS system is lower than dose levels reported when using conventional radiological systems, there is still present ionizing radiation. Our presented measuring system is based on completely non-ionizing radiation, which is not harmful to patients at all.

**Comment 4:**
"It lacks a comparison between internal curves obtained from radiography and external curves obtained by the laser, because the interest of the subject is only the transfer function between the internal curve and the external curve."

**Our response:**
We are aware that the determined spatial spine curves with the presented method are not identical to those determined using the X-ray methods. The main reason for the difference is related to vertebral axial rotation in the transverse plane. This is mentioned in our manuscript on page 10. However, the research topic in our manuscript was to compare the manual curves, obtained from palpation and automatic spine curves, obtained from the 3D depth image. A comparison between the internal curves obtained from radiography and external curves obtained by the laser triangulation method was also not our research topic.

**Editorial team:**
According to constructive comments, made by the reviewers, manuscript was slightly modified. Changed text is marked by red font color.

**Comment 1:**
"Please also clarify if you have obtained consent to publish the images in figures 2, 3 and 7 from the participants."

**Our response:**
All authors of the submitted manuscript have given a consent to publish the images in figures 2, 3 and 7.

Yours sincerely,

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     Dušan Čelan
     Janez Možina
     Matija Jezeršek

Ljubljana, October 16th, 2014