ROYAL ACADEMY OF ENGINEERING

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Engineering for orthopaedic applications

Towards predicting the effectiveness of knee surgery for knee osteoarthritis patients.

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Introduction

Osteoarthritis (OA) is the commonest form of musculoskeletal disability. Surgery is usually used to manage the end stage of the disease taking the form of either total joint or unicompartmental replacement. The outcome of such surgeries however could be disappointing. This work aims to exploit machine learning [1] to predict the effectiveness of surgery with respect to return to normal activities, as assessed using the Tegner activity score.

Methods

Ten subjects (56.3± 16.0 years old, 5 males and 5 females) presenting for knee resurfacing or joint replacement surgery were assessed prior to and following surgery (6.1±3.1 months post op). Each subject was asked to walk along a 6 metre walkway 1-3 times while data was captured at 100 Hz using 10 cameras to track the motion. Joint angles at the pelvis, hip, knee, ankle, and foot, moments as well as forces and moments at the hip, knee, and angle were determined using a custom model. For all the aforementioned angles, forces, and moments we consider three axes: sagittal, frontal, and transverse.

A regression tree was used to predict the effectiveness of the surgery given the subjects kinetics and kinematics before the surgery. Specifically, we computed statistical descriptors for the aforementioned angles, forces, and moments, namely: mean, max, min, and standard deviation. To assess the effectiveness of the surgery, the difference in Tegner activity score before and after surgery is computed. Due to the small number of subjects, data derived from 9 subjects were used to train the tree and the remaining one for testing.

Results

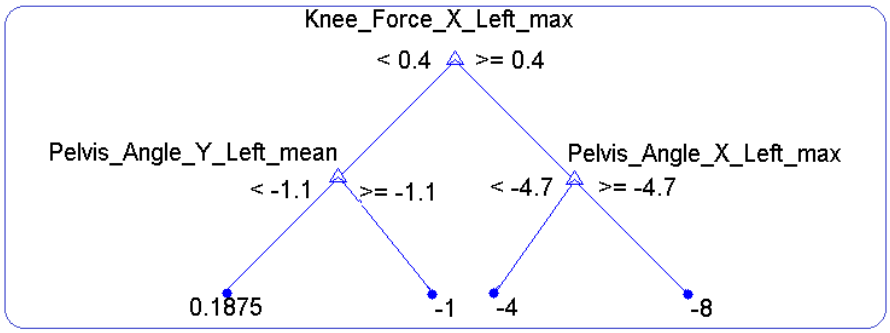


Figure 1: The regression tree, trained on statistics of the kinematics and kinetics. The leaves correspond to the difference of the Tegner activity score pre- and post- operative.

For the training subject, the actual difference in Tegner activity score before and after surgery coincides with the one predicted by the regression tree, meaning that this method achieves perfect accuracy.

Discussion

This is a pilot study on limited preliminary data that aims to indicate that machine learning may have vast potential in pushing the boundaries of orthopaedic surgery research via predicting the effectiveness of knee surgery. However, due to the limited number of patients, it should be underlined that this pilot study is a proof of concept and that further studies are required to validate these findings.

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References

[1] Levinger et al, 2009, “The application of support vector machines for detecting recovery from knee replacement surgery using spatio-temporal gait parameters”, Gait & Posture, 29, pp 91-96.