BRIGHAM AND
WOMEN'S HOSPITAL

HARVARD
MEDICAL SCHOOL

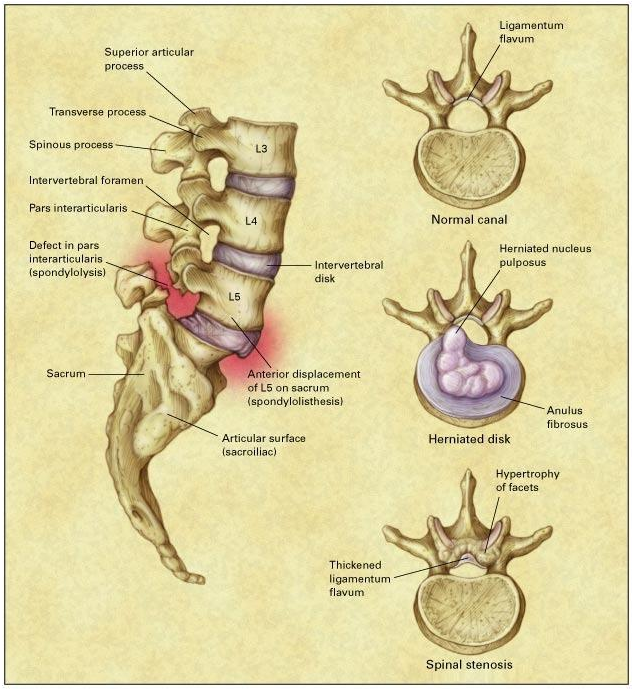
Model Spine Kinematics using a Game Physics Engine

The Image and Model Guided Neurosurgery Laboratory

We are computer scientists and engineers with backgrounds in computer vision, computer graphics and physics-based modeling. We work closely with neurosurgeons and neuroradiologists at Brigham and Women's Hospital to develop new tools for planning and guiding neurosurgery.

Background

We were recently approached by a neuro-radiologist who would like to address the high failure rate of surgery for lower back pain. Failures can occur because it is difficult to precisely locate the pain source in medical images. Images are acquired when the patient is lying on their back, while pain often occurs when sitting or walking. It is likely that changes in posture affect pinching of the nerves leaving the spine and that this effect is not visible in static images. We aim to build a kinematic model of the lower back to find locations and postures where nerves are being pinched.



A physics engine is a software library for modeling physical interactions between graphical models, including rigid-body dynamics, soft-body dynamics, collision detection, and fluid dynamics. High precision engines have precise physics and accurate computation and are used for scientific investigation and high-end computer animation. Real-time physics engines use simplified calculations to provide real-time simulation and are often used in computer games. There are many commercial and open-source game engines available. Quality, supported features, availability, and ease of use vary significantly.

Project description

In this project, you will investigate the use of off-the-shelf game physics engines to perform kinematic modeling of the lower back. You will compare features, availability, support, and user feedback for multiple engines. You will select 2-4 promising game engines, rig up a model of a single joint in the lower back (including two rigid vertebrae and the deformable disc between them) in each engine, and compare how well the game engines are able to model joint kinematics.

Components

The project has the following components

1. Research game physics engines and create a spread sheet to compare their features, reviews, availability, support community, how they are maintained, hardware requirements, etc.
2. Select 2-4 of these engines that you believe would be best for modeling the kinematics of the spine. Download and install these engines.
3. Obtain 3D models of one joint in the lower back (lumbar spine), i.e., two vertebrae and a vertebral disc.
4. Rig the models in each engine to simulate bending and twisting of the joint
5. Compare the simulations for speed and realism
6. Compare the selected engines according to features, ease of installation, support, ease of use, etc.

Contact

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Background reading

Clinical information about the spine

- Dr. Brian Su - The Spine Guy - YouTube
- Lumbar Spine Anatomy - YouTube

Physics Engines (includes list of open-source and commercial physics engines)

- Physics engine - Wikipedia

Some model sources (examples)

- "lumbar vertebrae" 3D Models to Print - yeggi
- 3D Lumbar Models | TurboSquid
- Human Spine Articulated 3D model 3D printable | CGTrader

Research paper

- An open-source musculoskeletal model of the lumbar spine and lower limbs: a validation for movements (tandfonline.com)