Prifysgol Cymru
Y Drindod Dewi Sant
University of Wales
Trinity Saint David

A Joint Constraint Model Using Signed Distance Fields

William Thomas Perkins • wperkins.I43204@student.uwtsd.ac.uk • University of Wales Trinity Saint David, Mount Pleasant, Swansea, SA1 6ED

Introduction

Joint constraints allow for the realistic movement of skeletons in animation, by preventing unrealistic rotations of skeleton joints. Distance Fields can be used as an accurate method of joint constraining, by first identifying infeasible joint positions, and correcting the position to the nearest feasible position [1].

Engell-Nørregard, et al. suggest that signed distance fields are able to offer a higher quality of resemblance to base motion capture references, when compared to other approaches [1].





Comparison of box-limit vs. distance cones [1]
Left: Distance cone. Middle: Motion Capture Reference. Right: Box-limit

IK movements see major usage in computer animation, but also in other fields such as medical applications. Computationally quicker and more accurate methods of joint constraining are becoming desireable [2].

Tools and Resources

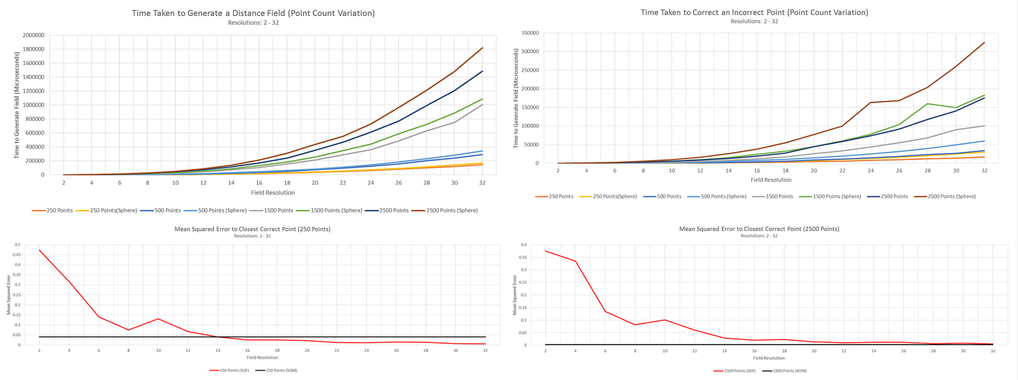
Development: C++ / Automated experiments: Python
C++ offers vast libraries and low level access to develop high performance applications.
Testing: Google Test
The Google Test framework offers a excellent means of building test harnesses during application development.
Version Control: GitHub
GitHub is a free and reliable service that offers project source backups and version control for code. Statistics offered by the service aid with project time management.

Project Aim & Objectives

Develop a joint constraining apparatus that uses a 3-dimensional distance field, and execute and evaluate a broad spectrum of experiments to determine the feasibility and performance of the model, and to compare the accuracy of the technique when compared to existing approaches.

- Conduct a literature review of distance fields, joint movement, joint constraining and existing joint constraining techniques; evaluating accuracy and performance where applicable.
- Construct a Signed Distance Field apparatus that's capable of generating a signed distance field of valid points, by using motion capture data. The apparatus must also be capable of correcting invalid points to the closest correct point.
- Generate accuracy and performance metrics of the Signed Distance Field approach, by providing the application with point cloud data sets in the SNNS format, where the file contains both valid points for constructing the Signed Distance Field, and invalid points that are corrected to the nearest boundary.
- Compare the accuracy and performance metrics of the Signed Distance Field approach against existing approaches.

Project Results



References

[1] M. Engell-Nørregard, S. Niebe and K. Erleben, "Local Joint-Limites using Distance Field Cones in Euler Angle Space.", Copenhagen
[2] G. L. Jenkins and M. E. Dacey, "A Unit Quaternion Based SOM for Anatomical Joint Constraint Modelling", 2014

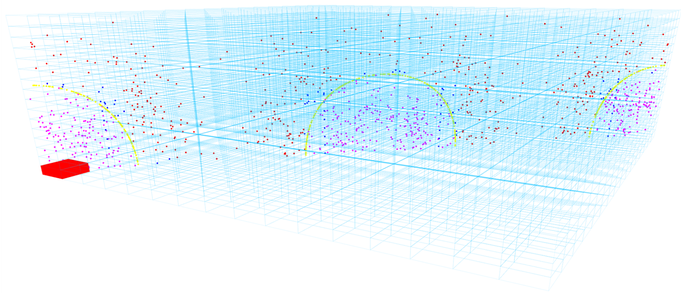
Variables

Independent Variables
Distance Field Resolution *(2x2x2 - 256x256x256)*
Point cloud swing angle *(10 - 170 degrees)*
Point cloud count *(250 to 2500)*
Target sphere optimisation *(On/off)*

Dependent Variables
Mean squared error
Memory requirement
Distance field generation time
Mean time taken to correct an incorrect rotation

Visualisation

Generated Distance Field
The distance field below uses a resolution of 16 x 16 x 16. A point cloud of 250 ZYZ Euler Angle points is used in this distance field.



Correct Cells
The distance field below is identical to the above. Cells with a value of 0 are highlighted in orange, representing areas of the field that signify a valid joint rotation.

