Thesis project at Gleechi AB
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Multi-Limb Inverse Kinematics

About Gleechi:
Gleechi is a Stockholm-based startup that have developed the first software to make it possible to animate hands that can move and interact freely and realistically in games and Virtual Reality. The technology is based on 8 years of robotics research, and the company now has customers including one of the top 10 largest VR developers in the world as well as a world-leading automation company. Gleechi has received several awards, including Super Startup of 2015 by Veckans Affärer and ALMI Invest and Winner of the european competition EIT Digital Idea Challenge 2015.
Video demo: https://www.youtube.com/watch?v=xkCt17JHEzY

Introduction:
Avatars in video games are commonly represented as chains of articulated joints which model the kinematic structure of the different parts of the avatar body, including the legs, arms and hands.
Rotating a joint modifies the position and orientation of the joints and links which are located further down in the chain; the mathematical computation of these positions dependent on the joint angles is called **forward kinematics**. On the other hand, it is generally more interesting and challenging to calculate the joint angles of a kinematic chain that correspond to a given position in cartesian space. This inverse mapping is known as **inverse kinematics (IK)** and has a number of useful applications in robotics and animation/computer graphics. In motion capture, joints on the human body are measured in cartesian space, and inverse kinematics is applied to reflect the joint angles on a virtual avatar. Many robotic manipulation tasks such as pick-and-place are easier to model and control in cartesian space, while inverse kinematics can then yield the corresponding joint control signals.

In this thesis project we will focus on inverse kinematics for kinematic chains with multiple limbs such as the human hand. This is specially relevant in the context of **grasp synthesis** in VR games**,** i.e. how to place the wrist and the fingers of a hand on a virtual object in order to grasp it. Many grasp planning algorithms initially calculate the contact locations of the fingertips on the surface of the object without considering the kinematics of the hand [1]. It is then up to an IK solver to provide a feasible joint configuration for each of the limbs (fingers) as well as the location of the wrist that can achieve such a grasp.

Description:
Although many different IK solvers have been proposed in the literature [2, 3, 4], multi-limb structures such as human hands pose a significant challenge due to their high kinematic complexity with 5 limbs (fingers) and more than 20 joints [5]. Furthermore, a problem that is often not considered in such solvers is the positioning of the wrist relative to the object, which significantly expands the search space for a solution. Learning methods have been proposed for robotic grasping to cope with these issues [6]. However, these learning approaches need to be trained for every hand model, which may not always be feasible in a VR gaming context. The purpose of this thesis is to design and evaluate a multi-limb IK solver that can tackle these issues while being implementable in real time.

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Tasks:

- Summarize state of the art IK solvers for multi-limb kinematic chains. Highlight advantages/disadvantages with each method.
- Design and evaluate an IK solver that takes into consideration kinematic constraints such as joint limits and the wrist placement problem.
- Integrate the solution with kinematic constraints of an anthropomorphic arm.
- Integrate the solution into Gleechi's VR demo platform.

Supervisor at Gleechi: Dr. Francisco Vina

References:

[1] http://www.csc.kth.se/~kaiyuh/pdfs/hang2014a.pdf
[2] http://www.andreasaristidou.com/publications/CUEDF-INFENG,%20TR-632.pdf
[3] https://www.math.ucsd.edu/~sbuss/ResearchWeb/ikmethods/iksurvey.pdf
[4] https://ece.uwaterloo.ca/~dkulic/pubs/SamadaniEMBC2012.pdf
[5] https://www.eng.yale.edu/grablab/pubs/Bullock_BIOROB2012.pdf
[6] http://www.csc.kth.se/~kaiyuh/pdfs/hang2016a.pdf
[7] http://www.dgp.toronto.edu/~gelkoura/noback/scapaper03.pdf

Application info:

Last apply date:	2016-12-31
Project work period:	Estimated to be 2017 Jan - July
Assignment type:	Degree project
Credits:	30 hp
How to apply:	Please email us your CV, transcript and an one-page personal letter.