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Institute for Systems and Robotics | LISBOA

Improved Eye Muscle Model- Curved Muscles

José Maria Noronha

jose.noronha@tecnico.ulisboa.pt

Ricardo Valadas

ricardo.v.valadas@tecnico.ulisboa.pt

LARSyS Laboratory of Robotics and Engineering Systems

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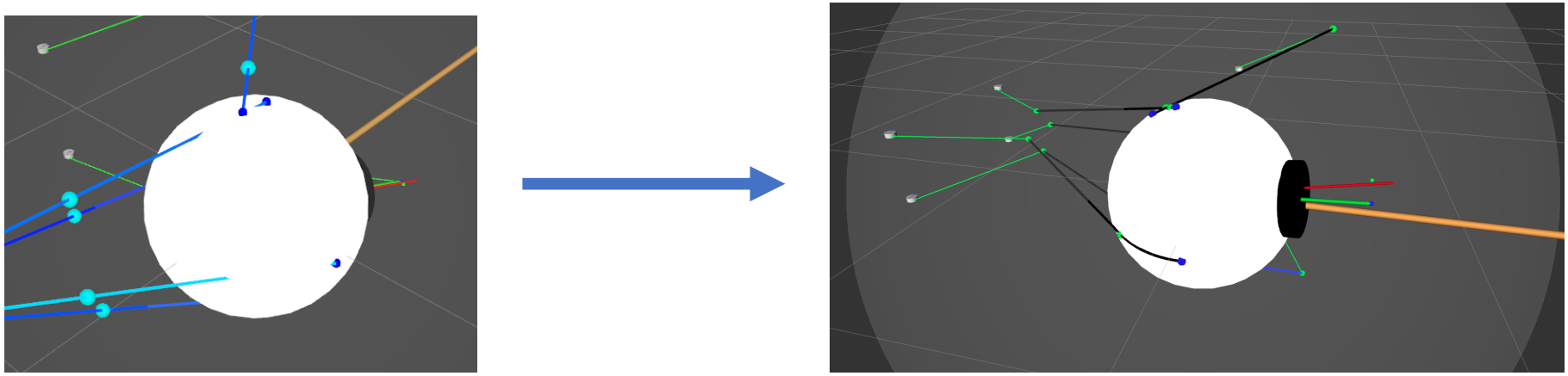
VISLAB

Objectives

- Model curved muscles



- Analyze muscle side slip on the eye

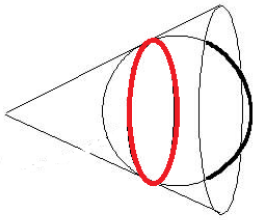
Curved Muscles Model

Known 1- Insertion point on the head

2- Tangent point on the eyeball

Known 3- Insertion point on the eyeball

Infinite possibilities. How to choose?

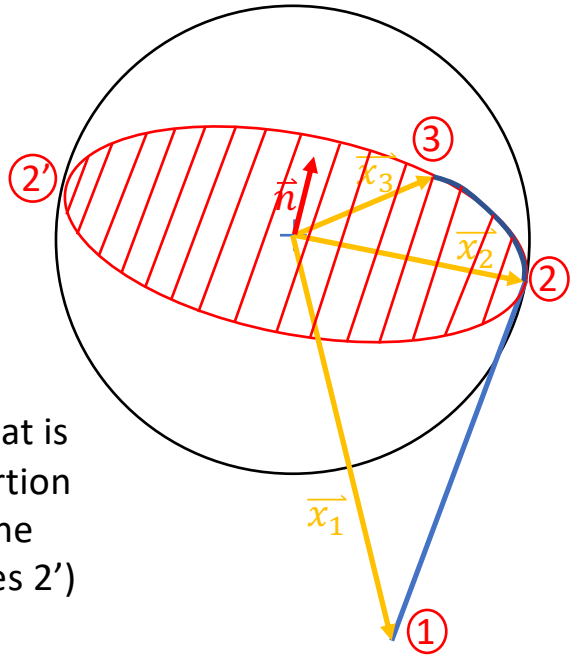


Assumption: minimize distance covered by the string on the eyeball (2-3) without friction

Geodesic

- Conditions:
  - 2 belongs to the plane that contains the geodesic
  - 2 belongs to the sphere
  - 2 is a tangent point

$$\begin{cases} \vec{n}\cdot\overrightarrow{x_2}=0 \\ \|\overrightarrow{x_2}\|=R \\ (\overrightarrow{x_2}-\overrightarrow{x_1})\cdot\overrightarrow{x_2}=0 \end{cases} \Leftrightarrow \begin{cases} (\overrightarrow{x_1}\times\overrightarrow{x_3})\cdot\overrightarrow{x_2}=0 \\ \overrightarrow{x_2}\cdot\overrightarrow{x_2}=R^2 \\ \overrightarrow{x_1}\cdot\overrightarrow{x_2}=R^2 \end{cases}$$



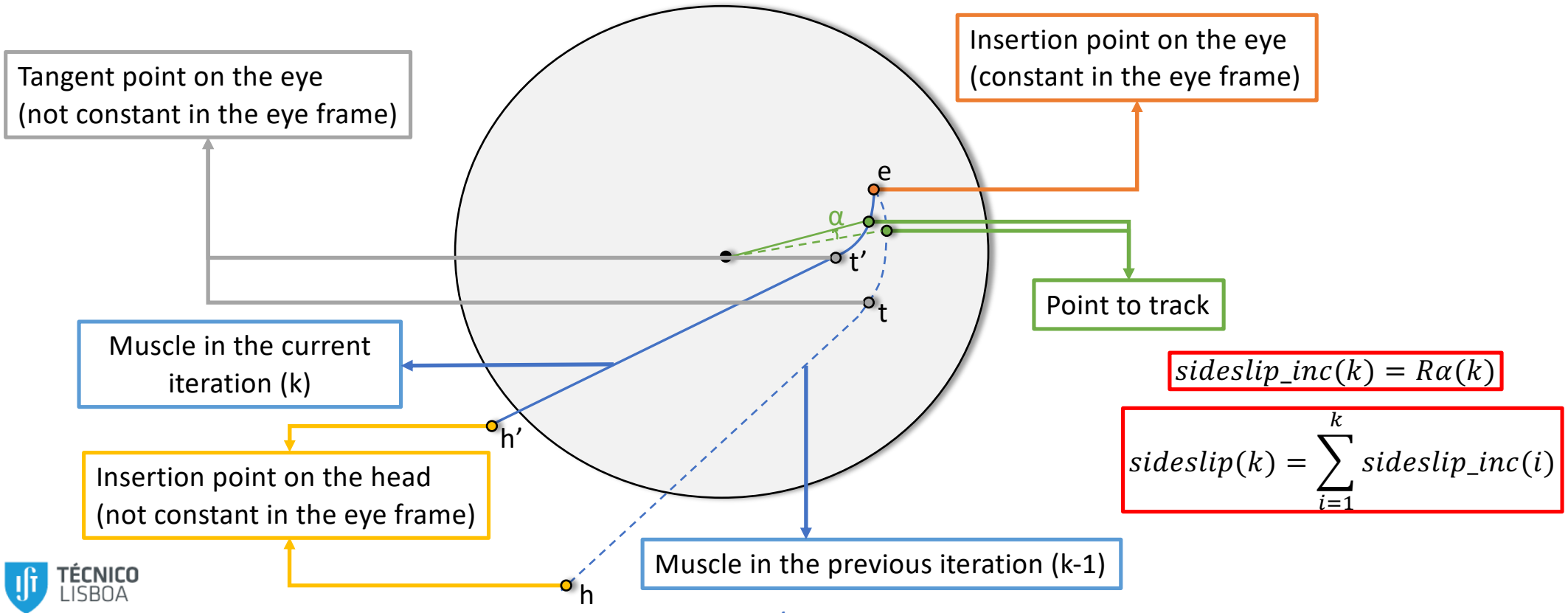
- Solution:

$$\overrightarrow{x_2}=\left(\frac{R}{\|\overrightarrow{x_1}\|}\right)^2\overrightarrow{x_1}\pm\left(\frac{R}{\|\overrightarrow{x_1}\|}\sqrt{1-\left(\frac{R}{\|\overrightarrow{x_1}\|}\right)^2}\right)(\vec{n}\times\overrightarrow{x_1})$$

Choose the one that is nearer to the insertion point in the eye (the other solution gives 2')

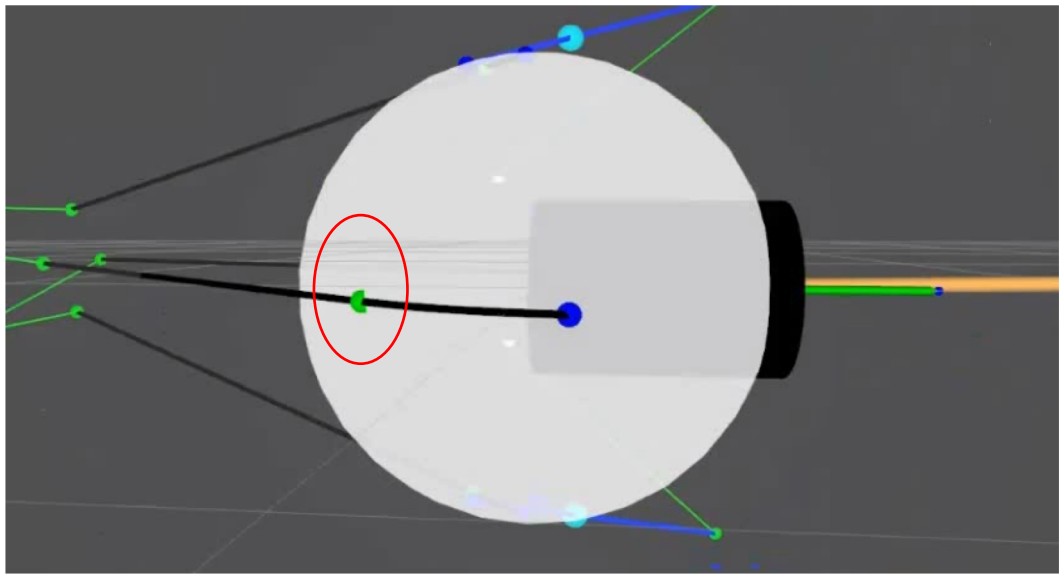
Muscle Side Slip

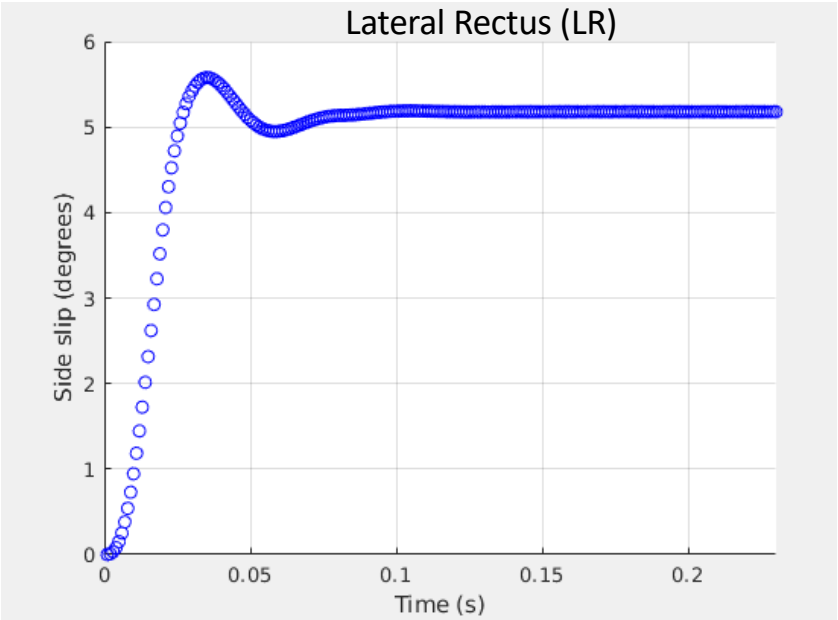
Eye Reference Frame



Side Slip- 45° upwards vertical saccade

Eye Reference Frame





Future Work

- Update the optimal control for the new model
  - New cost function that minimizes effort based on the new model
- Develop an even more biomimetic solution
  - Model the muscle as a mesh (or many curved lines) with several insertion points