# Motion Control of the Twente Humanoid Head

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## 1 Abstract

In this work, we present the design and the realization of the motion control algorithm implemented in the Twente humanoid head, a seven degrees of freedom (dof) robotic system. The aim of the project is to have a humanoid head that can serve as a research platform for human-machine interaction purposes. The head should not only be able to percieve its environment and track objects, but also be able to move in a human-like way, i.e. to reproduce the motions of human beings and to mime the human expressions. The Twente humanoid head is presented in Fig. 1.

**Figure 1:** The Twente humanoid head.

The mechanical design consists of a four dof head-neck structure and a three dof vision system. Two dofs of the neck are combined in a differential drive setup on which the other two dofs are mounted. The cameras of the vision system share a commmonly actuated tilt axis and can rotate sideways independently. The mechanical design is treated in detail in [2].

A vision processing algorithm analyzes the camera images and extracts the target information in the image plane, as deeply explained in [3]. This target can be either an object or a particular feature in the image plane and it provides the input of the control algorithm.

The mechanical structure has been translated into kinematic and dynamic models based on screw theory. The relation between the change in perceived 2D target coordinates, denoted by $\dot{\mathbf{x}}$, and the generalized joint velocities $\dot{\mathbf{q}}$ is

$$\dot{\mathbf{x}} = \mathbf{F}(\mathbf{q})\dot{\mathbf{q}} \tag{1}$$

where $\mathbf{F}(\mathbf{q})$ is a matrix mapping as function of the generalized joint positions $\mathbf{q}$. From this relation, given a desired $\dot{\mathbf{x}}$, the joint velocities $\dot{\mathbf{q}}$ can be obtained through the relation

$$\dot{\mathbf{q}} = \mathbf{F}^{\sharp}\dot{\mathbf{x}} + \left(\mathbf{I} - \mathbf{F}^{\sharp}\mathbf{F}\right)\mathbf{z} \tag{2}$$

where $\mathbf{F}^{\sharp}$ is a generalized inverse of matrix $\mathbf{F}$ and $\mathbf{z}$ is an arbitrary vector of appropriate dimension which is projected onto the null space of $\mathbf{F}$, see [1] for more details. Vector $\mathbf{z}$ can be both used to generate human-like motions of the head in the tasks of target tracking and to generate motions in the null-space so to realize certain expressions, or human-like behavior, that can be exploited in human-machine interaction. The controller overview, presented in Fig. 2, has been implemented in 20-sim simulation software [4] for the preliminary tests and, then, in the real setup.

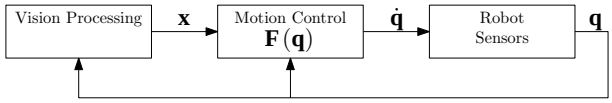


**Figure 2:** Control scheme.

Finally the expression movements have been coupled to the movement of the eyelids and the eyebrows, realized with a LED system which projects light from the internal part of the plastic cover of the head.

## References

[1] L.C. Visser, R. Carloni and S. Stramigioli, "Vision based motion control for a humanoid head", *Master's Thesis, University of Twente*, 2008.

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[3] R. Reilink, S. Stramigioli, F van der Heijden and G. van Oort, "Saliency-based humanoid gaze emulation using a moving camera setup", *Master's Thesis, University of Twente*, 2008.

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