Animatronic model of a human tongue

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Contemporary speech technology struggles with the variation that occurs in natural speech. In order to explain such variation, researchers frequently refer to processes of energy optimisation that govern speech production. Although there is plenty of qualitative evidence, quantitative data about speech energetics are still sparse because it is difficult to acquire them from human subjects. To overcome this problem, an animatronic model of a human tongue and vocal tract (AnTon) was designed. Human anatomy provided the guideline for its construction; functional considerations were made only when an approximation using available technology proved impossible or infeasible. Thus, the behaviour of the model derives from, and is grounded in, its anatomy. The tongue model presented here was developed using these 'biomimetic' principles. The human tongue consists almost completely of interwoven muscle fibres whose topology allows for complex movements. The incompressibility of muscle tissue is an important prerequisite, a property it shares with water; such structures are therefore called 'muscular hydrostats'. The soft silicon that forms the artificial tongue body approximates incompressibility. Muscles are represented by filaments that run along paths resembling real muscle fibre orientation. Wherever muscle fibres follow a curved path, regularly spaced glass beads prevent filaments from cutting into the silicon. The filaments connect to meshes that are embedded into the tongue body and serve both as an attachment point and to distribute force evenly. The current tongue model comprises four of the main tongue muscles, represented by eleven filaments that are attached to servo motors. It is connected to a movable jaw and a hyoid bone; the latter is a horseshoe-shaped bone that supports the tongue root and is situated directly above the Adam's apple. AnTon is able to imitate a range of oral gestures and will be used for sound production as soon as the anterior part of the vocal tract is completed. Apart from studying speech energetics, AnTon has the potential to become a general tool for speech research, education, and speech therapy. A video is available on the AnTon project's website: http://www.dcs.shef.ac.uk/ robin/anton/anton.html.