UNIVERSITY OF TARTU
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From the brain to intelligent systems: The attenuation of sensation of self-generated movement

Master's Thesis (30 ECTS)

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Summary: Despite the recent achievements of the artificial intelligence systems, humans are still remarkably more elegant in performing a variety of sensorimotor tasks in complex and dynamically changing environments. To build machines that could learn and think like people, one needs to understand the algorithms the human brain implements to interact with the world. For an intelligent machine to independently and flexibly cope with the highly dynamical environment, discriminating self-generated changes in the environment from those generated by external agents is of critical importance. In this study, we investigated a putative mechanism of how the sensory consequences of self-generated movements are processed in the human brain. The general idea with some experimental support is that the brain actively dampens the sensory consequences of movement produced by the brain itself. To test the generality of this mechanism we conducted virtual reality (VR) experiments with human subjects where - with the help of a hand tracking device - moving targets were presented behind their own moving (but for them invisible) hand. The data from two experiments indicate attenuation of movement signals when the targets were presented behind the hand. These insights about how to cope with the sensory consequences of self-generated movement are important for building intelligent autonomous systems.

Keywords: sensory attenuation, virtual reality, Leap Motion Controller, Oculus Rift, self-generated movements, intelligent systems

CERCS: P176, Artificial Intelligence

Ajust intelligentsete süsteemideni: enese tekitatud liikumisaistingute pidurdus

Summary: Hoolimata viimaste aastate kiiretest arengutest tehisintellekti valdkonnas on inimesed endiselt märkimisväärselt osavamad ülesannetes, mis puudutavad hakkamasaamist keerulises ja dünaamiliselt muutuvas keskkonnas. Inimsarnase õppimis- ja mõtlemisvõimega masinate ehitamiseks on vajalik kõigepealt mõista, kuidas inimaju maailmaga vastastikmõjus on. Selleks, et intelligentne masin suudaks pidevas muutumises olevas maailmas iseseisvalt ja paindlikult toimida, on masina jaoks oluline eristada iseenda poolt põhjustatud muutusi välise keskkonna mõjurite poolt tekitatud sisendist. Antud töös uurime mehhanismi, mida inimaju oletatavalt kasutab enda liigutustest põhjustatud tajukogemuse töötlemisel. Varasematest töödest on teada, et aju pidurdab aktiivselt sensoorseid signaale, mis on põhjustatud aju enda poolt kontrollitud jäsemete liikumisest. Antud töös testisime selle teooria üldkehtivust, viies katseisikutega läbi virtuaalreaalsuseksperimendid, kus katseisikud pidid tuvastama liikuvaid stiimuleid iseenda liikuva (kuid neile nähtamatu) käe tagant. Kahe eksperimendi andmed viitavad pidurdatud liikumistajule, kui eesmärkstiimulid kuvati liikuva käe taha. Teadmised selle kohta, kuidas inimaju töötleb iseenda tekitatud liikumisest tingitud sensoorseid tagajärgi on olulised autonoomsete masinate ehitamiseks.

Keywords: pidurdatud liikumistaju, virtuaalreaalsus, Leap Motion Controller, Oculus Rift, intelligentsed süsteemid

CERCS: P176, Tehisintellekt

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1 Main Part

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Conclusions

In order to build intelligent systems capable of human-like understanding of the world, the mechanisms of the higher cognitive functions of the human brain itself have to be understood. We explored the important computational problem of how the brain processes self-generated movement. Specifically, we hypothesized that the brain actively attenuates the sensory perception of the motion of the self-generated hand movement, and conducted two virtual reality experiments with human subjects to verify this hypothesis. We first observed that the moving targets behind the moving hand were processed slower than other targets. In the second experiment, we verified these results by showing that the effect was non-specific to the side of the visual field the targets were presented to. All in all, these data indicate that the brain could indeed attenuate the motion of self-generated movements to discriminate the sensory consequences of its own body movement from the movement in the environment. These knowledge could be used by developers and engineers for building intelligent systems capable of interacting with complex and dynamic environment.

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