Eye tracker

Koskinen et al. in a case study, applied a detector with a microscope eye tracker to investigate tool use and eye-hand coordination during an intracranial vessel dissection task. The results show that tool kinematics differentiate microsurgical actions. The gaze-to-microscissors distances are also smaller during dissection than other actions when the surgeon has more space to maneuver. The presented detection pipeline provides the clinical and research communities with a valuable resource for automatic content extraction and objective skill assessment in various microsurgical environments [1)].

The Tobii eye-tracker was used to record surgeons' eye movements while they performed a micro suturing task. A total of 19 experts and 18 novice trials were recorded under the microscope. Surgical videos were annotated to label subtasks and critical actions. Total suturing time and subtask times were also compared between novice and expert surgeons. At 3 critical and discrete surgical actions (needle piercing into the tissue, exiting, and thread cutting) they examined eye fixation that was directly coupled to each of these actions.

Compared with novices, expert surgeons completed the suture with shorter total time (258.52 ± 102.14 seconds vs. 330.02 ± 96.52 seconds, P = 0.038), penetration time (17.15 ± 3.50 seconds vs. 26.26 ± 18.58 seconds, P = 0.043), and knot-tying time (194.63 ± 94.55 seconds vs. 262.52 ± 79.05 seconds, P = 0.025). On average, experts displayed longer fixation (1.62 seconds) and preaction fixation time (1.3 seconds) than novices (fixation time = 1.24 seconds, P = 0.048; preaction fixation = 0.82 seconds, P = 0.005)). Experts maintained their visual engagement constantly over the 3 levels of subtasks while novices required a longer fixation time for the challenging piercing action than for the exiting and cutting action.

The action-related fixation can be used to evaluate microsurgeons level of expertise and in surgical education for gaze training [2)].

3: Mitsuhashi T, Sonoda M, Iwaki H, Sakakura K, Asano E. Detection of absence seizures using a glasses-type eye tracker. Clin Neurophysiol. 2021 Mar;132(3):720-722. doi: 10.1016/j.clinph.2020.12.015. Epub 2021 Jan 7. PMID: 33571880.

4: Oxley TJ, Yoo PE, Rind GS, Ronayne SM, Lee CMS, Bird C, Hampshire V, Sharma RP, Morokoff A, Williams DL, MacIsaac C, Howard ME, Irving L, Vrljic I, Williams C, John SE, Weissenborn F, Dazenko M, Balabanski AH, Friedenberg D, Burkitt AN, Wong YT, Drummond KJ, Desmond P, Weber D, Denison T, Hochberg LR, Mathers S, O'Brien TJ, May CN, Mocco J, Grayden DB, Campbell BCV, Mitchell P, Opie NL. Motor neuroprosthesis implanted with neurointerventional surgery improves capacity for activities of daily living tasks in severe paralysis: first in- human experience. J Neurointerv Surg. 2021 Feb;13(2):102-108. doi: 10.1136/neurintsurg-2020-016862. Epub 2020 Oct 28. PMID: 33115813; PMCID: PMC7848062.

5: McKendrick M, Sadler A, Taylor A, Seeley J, Filipescu T, Mustafa A, McKendrick G, Halcrow J, Raju P, McLeod GA. The effect of an ultrasound- activated needle tip tracker needle on the performance of sciatic nerve block on a soft embalmed Thiel cadaver. Anaesthesia. 2021 Feb;76(2):209-217. doi: 10.1111/anae.15211. Epub 2020 Aug 14. PMID: 32797700.

6: Wegner-Clemens K, Rennig J, Beauchamp MS. A relationship between Autism- Spectrum Quotient and face viewing behavior in 98 participants. PLoS One. 2020 Apr 30;15(4):e0230866. doi: 10.1371/journal.pone.0230866. PMID: 32352984; PMCID: PMC7192493.

7: McLeod GA, McKendrick M, Taylor A, Sadler A, Halcrow J, Mustafa A, Seeley J, Raju P, McKendrick G. An initial evaluation of the effect of a novel regional block needle with tip-tracking technology on the novice performance of cadaveric ultrasound-guided sciatic nerve block. Anaesthesia. 2020 Jan;75(1):80-88. doi: 10.1111/anae.14851. Epub 2019 Sep 10. PMID: 31506921.

8: van der Salm SMA, van der Meer JN, Cath DC, Groot PFC, van der Werf YD, Brouwers E, de Wit SJ, Coppens JC, Nederveen AJ, van Rootselaar AF, Tijssen MAJ. Distinctive tics suppression network in Gilles de la Tourette syndrome distinguished from suppression of natural urges using multimodal imaging. Neuroimage Clin. 2018;20:783-792. doi: 10.1016/j.nicl.2018.09.014. Epub 2018 Sep 19. PMID: 30268027; PMCID: PMC6169325.

9: Bin Zahid A, Hubbard ME, Lockyer J, Podolak O, Dammavalam VM, Grady M, Nance M, Scheiman M, Samadani U, Master CL. Eye Tracking as a Biomarker for Concussion in Children. Clin J Sport Med. 2020 Sep;30(5):433-443. doi: 10.1097/JSM.0000000000000639. PMID: 30095503.

10: Rennig J, Beauchamp MS. Free viewing of talking faces reveals mouth and eye preferring regions of the human superior temporal sulcus. Neuroimage. 2018 Dec;183:25-36. doi: 10.1016/j.neuroimage.2018.08.008. Epub 2018 Aug 6. PMID: 30092347; PMCID: PMC6214361.

11: Eivazi S, Hafez A, Fuhl W, Afkari H, Kasneci E, Lehecka M, Bednarik R. Optimal eye movement strategies: a comparison of neurosurgeons gaze patterns when using a surgical microscope. Acta Neurochir (Wien). 2017 Jun;159(6):959-966. doi: 10.1007/s00701-017-3185-1. Epub 2017 Apr 19. PMID: 28424915.

12: Fanous AA, White TG, Hirsch MB, Chakraborty S, Costantino PD, Langer DJ, Boockvar JA. Frameless and Maskless Stereotactic Navigation with a Skull-Mounted Tracker. World Neurosurg. 2017 Jun;102:661-667. doi: 10.1016/j.wneu.2017.03.007. Epub 2017 Mar 12. PMID: 28300710.

13: Samadani U, Farooq S, Ritlop R, Warren F, Reyes M, Lamm E, Alex A, Nehrbass E, Kolecki R, Jureller M, Schneider J, Chen A, Shi C, Mendhiratta N, Huang JH, Qian M, Kwak R, Mikheev A, Rusinek H, George A, Fergus R, Kondziolka D, Huang PP, Smith RT. Detection of third and sixth cranial nerve palsies with a novel method for eye tracking while watching a short film clip. J Neurosurg. 2015 Mar;122(3):707-20. doi: 10.3171/2014.10.JNS14762. Epub 2014 Dec 12. PMID: 25495739; PMCID: PMC4547625.

14: Gomez-Ibañez A, Urrestarazu E, Viteri C. Recognition of facial emotions and identity in patients with mesial temporal lobe and idiopathic generalized epilepsy: an eye-tracking study. Seizure. 2014 Nov;23(10):892-8. doi: 10.1016/j.seizure.2014.08.012. Epub 2014 Sep 22. PMID: 25277844.

15: Di Stasi LL, McCamy MB, Macknik SL, Mankin JA, Hooft N, Catena A, Martinez- Conde S. Saccadic eye movement metrics reflect surgical residents' fatigue. Ann Surg. 2014 Apr;259(4):824-9. doi: 10.1097/SLA.0000000000000260. PMID: 24169184.

16: Suenaga H, Hoang Tran H, Liao H, Masamune K, Dohi T, Hoshi K, Mori Y, Takato T. Real-time in situ three-dimensional integral videography and surgical navigation using augmented reality: a pilot study. Int J Oral Sci. 2013 Jun;5(2):98-102. doi: 10.1038/ijos.2013.26. Epub 2013 May 24. PMID: 23703710; PMCID: PMC3707071.

17: Fridley J, Adams G, Sun P, York M, Atassi F, Lai E, Simpson R, Viswanathan A, Yoshor D. Effect of

subthalamic nucleus or globus pallidus interna stimulation on oculomotor function in patients with Parkinson's disease. Stereotact Funct Neurosurg. 2013;91(2):113-21. doi: 10.1159/000343200. Epub 2013 Jan 22. PMID: 23343617.

18: Salman MS, Sharpe JA, Lillakas L, Steinbach MJ, Dennis M. Smooth ocular pursuit in Chiari type II malformation. Dev Med Child Neurol. 2007 Apr;49(4):289-93. doi: 10.1111/j.1469-8749.2007.00289.x. PMID: 17376140.

19: Salman MS, Sharpe JA, Eizenman M, Lillakas L, To T, Westall C, Steinbach MJ, Dennis M. Saccades in children with spina bifida and Chiari type II malformation. Neurology. 2005 Jun 28;64(12):2098-101. doi: 10.1212/01.WNL.0000166034.71337.5E. PMID: 15985580.

20: Schlosser HG, Unterberg A, Clarke A. Using video-oculography for galvanic evoked vestibulo-ocular monitoring in comatose patients. J Neurosci Methods. 2005 Jun 30;145(1-2):127-31. doi: 10.1016/j.jneumeth.2004.12.004. Epub 2005 Jan 7. PMID: 15922031.

1)
Koskinen J, Torkamani-Azar M, Hussein A, Huotarinen A, Bednarik R. Automated tool detection with deep learning for monitoring kinematics and eye-hand coordination in microsurgery. Comput Biol Med. 2022 Feb;141:105121. doi: 10.1016/j.compbiomed.2021.105121. Epub 2021 Dec 11. PMID: 34968859.

2)
Chainey J, Elomaa AP, O'Kelly CJ, Kim MJ, Bednarik R, Zheng B. Eye-Hand Coordination of Neurosurgeons: Evidence of Action-Related Fixation in Microsuturing. World Neurosurg. 2021 Nov;155:e196-e202. doi: 10.1016/j.wneu.2021.08.028. Epub 2021 Aug 13. PMID: 34400325.