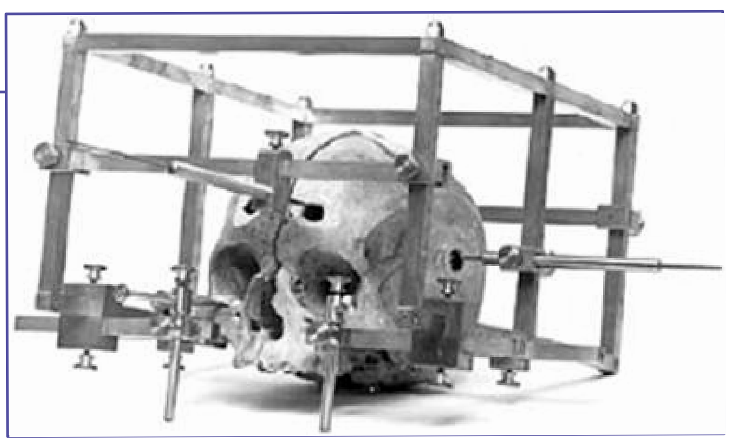
A Timeline of Surgical Robotics

By Mary Reilly

Stereotaxic Surgery, 1908



Widely considered the first medical robot, the stereotaxic frame was devised and tested on monkeys by Victor Horsley and Robert Clarke in 1908. Horsley and Clarke developed the frame based on the emerging theory that regions of the brain could be located using external features of the skull. This frame was posited to revolutionize neurosurgery by assisting surgeons with the accurate targeting of and steady approach to lesions on specific brain structures in 3D space (Rahman et al., 2009).

ROBODOC, 1992

ROBODOC performed the first active robotic surgery on a human in 1992, executing portions of a total hip arthroplasty with complete autonomy (Sugano, 2013). The ROBODOC system was developed to select the most appropriate femoral implant for the patient and to mill out the socket in the bone that would hold the artificial hip with a much greater precision than human hands ever could, staying within a miniscule tolerance. During surgery, the ROBODOC carried out actions programmed by surgeons before the first incision. In later years, ROBODOC evolved to assist surgeons with the mapping of preoperative images and the surgeon's theoretical routes to the physical locations within the patient's body on the operating table via improved calibration and registration procedures. As of March 2021, the ROBODOC remains the sole active robotic systems approved for orthopedic surgery by the Food and Drug Administration (THINK Surgical, 2018).

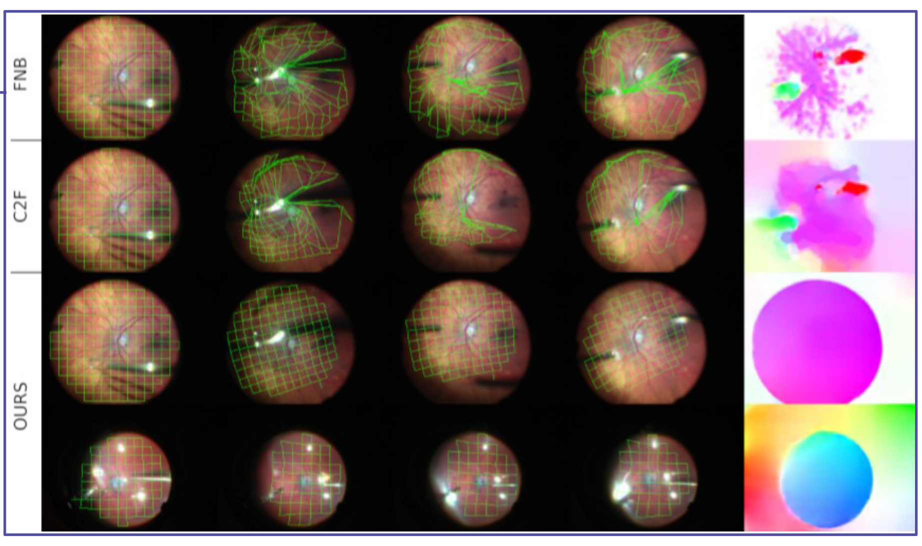
da Vinci, 2000

In 2000, the da Vinci surgical system gained FDA for heart surgery, cholecystectomy, and other laparoscopic surgeries. The da Vinci system incorporates live three-dimensional laparoscope views and haptic feedback from the hand controls to compensate for the disadvantages of typical laparoscopic systems and virtually immerse the doctor in the surgery. In addition to the creation of a virtual operative field, the da Vinci surgical system filters out hand tremors and parses the surgeon's movement down by a 5:1 ratio, allowing the surgeon to make naturally sized movements even when operating on a scale smaller than their unaided hand ever could. (Pugin et al, 2011). The da Vinci is most notable for its ability to mimic the dexterity of the human wrist with its instrument arms that have seven degrees of freedom and for its ability to provide the surgeon with depth perception via stereoendoscopes. These factors, among others, have led to the da Vinci's widespread adoption and commercial success (Bergeles & Yang, 2014).

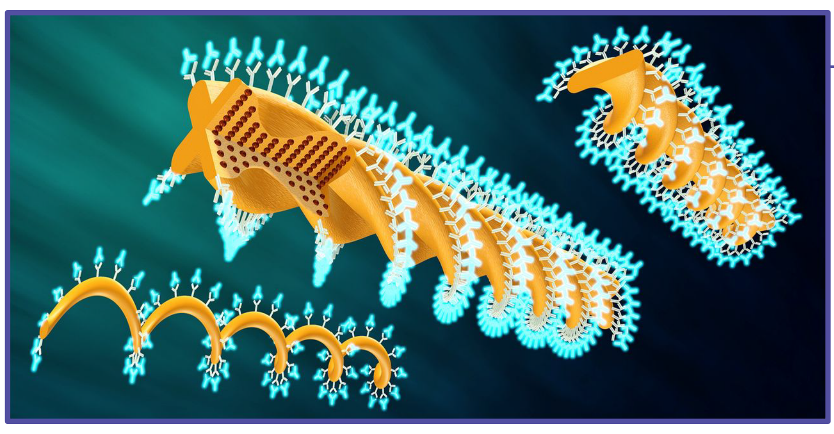
ZEUS, 2001

The ZEUS robotic surgical system was the main competitor of the da Vinci system, boasting similar filtering and movement scaling functionalities and a voice-controlled endoscope (Bergeles & Yang, 2014). On September 7, 2001, the ZEUS system was used to perform the first transatlantic telesurgery, a 54-minute laparoscopic cholecystectomy dubbed "Operation Lindbergh." With the help of the ZEUS system, a fiberoptic cable network, and dedicated teams of doctors on both sides of the ocean, a surgeon located in New York operated on a patient in Strasbourg, France with no technical issues, proving that telerobotic surgery was not only a possibility, but an attainable reality (Pugin et al, 2011).

Machine Learning in Surgery, 2020



Dr. Christos Bergeles and his research lab at King's College London designed and tested a soft-bodied robot that aids ophthalmologists with retinal surgery. This robot utilized deep machine learning and neural networks to filter out tools, shadows, glare, and other obstructions that hindered surgeons' ability to track movements of the retina during surgery. The neural network was trained with synthetic data and tested on real intraoperative retinal surgery videos. The use of machine learning and neural networks make this project among the state of the art for modern surgical robotics (Ravasio et al., 2020).



Beyond...

Experts on surgical robotics have many hopes and theories for the trajectory of the future of the field. Dr. Bergeles believes that medical robots will continue to dramatically decrease in size, which will allow them to interact with the body on a microscopic level. Such robots will push the boundaries of micromedicine—delivering highly specialized and concentrated treatments to exactly the locations that need them. Microscopic medical robots may prove to be a vital ingredient in the cure for cancer or neurological diseases like Alzheimer's or Parkinson's (Bergeles & Yang, 2014).

References

Bergeles, C., & Guang-Zhong Yang. (2014). From passive tool holders to microsurgeons: Safer, smaller, smarter surgical robots. *IEEE Transactions on Biomedical Engineering, 61*(5), 1565-1576. doi:10.1109/tbme.2013.2293815

Pugin, F., Bucher, P., & Morel, P. (2011). History of robotic surgery : From Aesop® and Zeus® to da Vinci®. *Journal of Visceral Surgery, 148*(5). doi:10.1016/j.jviscsurg.2011.04.007

Rahman, M., Murad, G. J., & Mocco, J. (2009). Early history of the stereotactic apparatus in neurosurgery. *Journal of Neurosurgery*. doi:10.3171/2009.7.focus09118

Ravasio, C. S., Pissas, T., Bloch, E., Flores, B., Jalali, S., Stoyanov, D., Cardoso, J., Da Cruz, L., Bergeles, C. (2020). Learned optical flow for intra-operative tracking of the retinal fundus. *International Journal of Computer Assisted Radiology and Surgery, 15*(5), 827-836. doi:10.1007/s11548-020-02160-9

Sugano, N. (2013). Computer-Assisted orthopaedic surgery and robotic surgery in total Hip Arthroplasty. *Clinics in Orthopedic Surgery, 5*(1). doi:10.4055/cios.2013.5.1.1

THINK Surgical. (2020, January 29). History. Retrieved April 01, 2021, from https://thinksurgical.com/company/history/

Image Credits

da Vinci XI Surgical System [Photograph]. (n.d.). Intuitive. https://www.intuitive.com/en-us/products-and-services/da-vinci/systems

Holloway, R. (2009). *ZEUS Robotic System.* [Photograph]. Emergence of robotic assisted surgery in gynecologic oncology: American perspective. *Gynecologic Oncology*. https://www.researchgate.net/figure/ZEUS-robotic-system-first-robotic-system-to-combine-instrument-and-camera-control_fig3_51437277

Ornes, S. (2017). [Animated rendering of microrobots devised by researchers at ETH Zurich]. Inner workings: Medical microrobots have potential in surgery, therapy, imaging, and diagnostics. *Proceedings of the National Academy of Sciences of the United States of America*. https://doi.org/10.1073/pnas.1716034114

Rahman, M. (2009). [Photograph of the human stereotactic apparatus developed by Mussen in 1918]. Early history of the stereotactic apparatus in neurosurgery. *Journal of Neurosurgery*. https://doi.org/10.3171/2009.7.FOCUS09118

Ravasio, C. (2020). *Illustration of grid tracking and flow field.* [Photograph]. Learned optical flow for intra-operative tracking of the retinal fundus. *International Journal of Computer Assisted Radiology and Surgery*. https://doi.org/10.1007/s11548-020-02160-9

Sugano, N. (2013). [Photograph of the ROBODOC surgical system]. Computer-assisted orthopaedic surgery and robotic surgery in total hip arthroplasty. *Clinics in Orthopedic Surgery*. https://www.ncbi.nlm.nih.gov/pmc/articles/PMC3582865/