Adjepong D, J Surg Curr Trend Innov 2020, 4: 030
DOI: 10.24966/SCTI-7284/100030

HSOA Journal of Surgery: Current Trends & Innovations

Review Article

# Adaptive Control Systems for Medical Robots in Neurosurgery: A Review

**Dennis Adjepong, MD, MBA***

*Department of Neurological Surgery, California Institute of Behavioral Neurosciences & Psychology, Fairfield, USA*

## Abstract

The paper seeks to explain the use of adaptive control systems in medical robots during neuro-surgery. The introduction will give an overview of the use of robots in surgery, specifically in neurosurgery. Neurosurgery is the pioneer of medical robots. The method that can be used in adaptive control systems is discussed later in the paper; this will then lead to the results of the study. This discussion involves the study of Alzheimer's Disease ( AD). The focus of the research is divided into the pathophysiology, biochemistry, genetics, unanswered questions, and scientific analysis of Alzheimer's Disease (AD).

**Keywords:** Adaptive Control System; Medical Robots; Robotic surgery

## Introduction

According to Avgousti et al. [1], medical surgery has advanced in various aspects of innovation and treatment. The technology used during the surgery depends on the type of surgery involved and the complexity of the procedure [2]. Neurosurgery consists of the medicine of the brain and complications associated with brain surgery [3]. However, there are limitations, such as detailed neural structures and various anatomical aspects [1,4]. Medical robots do not work autonomously.

It should be noted that medical robots were pioneered by neurosurgery. Depending on the interaction between the surgeon and the robot, there are three models of robotic surgery [5]. The three models include a supervisory control system, a telesurgery system, and a shared control system [6]. As stated by Chumnanve, Pillai, and Suthakorn [7], in robotics, an adaptive control system is essential to track the required trajectory in detail. Upon detailed analysis, it is determined that an adaptive control system should be incorporated into medical robots, specifically in robots that assist in neurosurgery.

***Corresponding author:** Dennis Adjepong, Department of Neurological Surgery, California Institute of Behavioral Neurosciences & Psychology, Fairfield, USA, Tel: +1 5712771998; E-mail: adjepongdennis1@gmail.com

**Citation:** Adjepong D (2020) Adaptive Control Systems for Medical Robots in Neurosurgery: A Review. J Surg Curr Trend Innov 4: 030.

**Received:** April 02, 2020; **Accepted:** April 08, 2020; **Published:** April 15, 2020



## Methods

Various methods are involved in the development and incorporation of an adaptive control system in medical robots. 4-Channel Architecture is used where it includes impedances, exogenous forces, and forces involving the operator and its environment [8]. There are various inputs from the slave robot and master robot. Also, their controllers, such as the local force and the local position [9]. The architecture has various aspects that aid in the stability of the medical robot during operation. Before surgery, errors associated with position tracking and force tracking should be considered. The errors should be as minimal as zero [10]. Also, all the signals should be bound during operation. The errors should be found for the controllers to function effectively and for the entire system to be stable and efficient in action [2].

## Results

The study involves various parts such as a hard cube, a phantom tissue, and a soft cube. A hard cube is used to control the system while the soft cube is a contact material. In this case, the phantom tissue functions as the environment for the operation of the controllers. A hard cube does not get deformed easily as compared to the soft cube. The tracking of position and force is excellent during contact [9]. There are minimum errors. Therefore, the system performs adequately in a non-linear model. From observation, it is determined that proper tracking of position can be well-achieved in both soft and hard tissue [11]. When free motion is used, adequate position tracking is accomplished. Therefore, the adaptive control system proves stability during operation.

## Discussion

### Pathophysiology of the disease

An instance where medical robots can be applied during surgery is when performing surgery on an Alzheimer's patient. Alzheimer's disease is a neural disorder that is an irreversible disorder that progresses spontaneously over time [12]. As suggested by Desai, Agrawal, and Ferreira [13], symptoms associated with Alzheimer's disease are classified as being cognitive or non-cognitive dysfunctions. Cognitive dysfunction includes symptoms such as memory loss, difficulty in languages, and executive dysfunctions [14]. Non-cognitive include symptoms such as, disturbances in behavior and some psychiatric symptoms, which include hallucinations, agitation, delusion, and depression [15]. The patient's cognitive performance dramatically decreases during the last stages. In the previous stages of such a patient, he or she needs assistance in performing their daily activities.

Various hypotheses are used to describe the pathophysiology [16]. The explanations include cholinergic hypothesis and genetic study.

### Biochemistry of the disease

Alzheimer's disease is believed to be a disease that involves a protein misfolding. The disease results from the accumulation of a protein referred to as amyloid-beta protein [17]. This protein accumulates in the patient's brain. It is a byproduct of the precursor protein. The precursor protein takes part in neural development [18]. The protein causing Alzheimer's is a monomer and is soluble. Also, the disease is known to be a tauopathy; this is because tau protein aggregates abnormally [19]. Tau protein is shown in neurons. The neurons are a stabilizer of the microtubules, found in the cytoskeleton of the brain. The level of neurotransmitters in Alzheimer's patients is significantly reduced (10). However, the FDA has approved a method that involves replenishing the level of neurotransmitters.

### Genetics of the disease

Over 90% of Alzheimer's patients seem sporadic. Alzheimer's disease is believed to onset from 60 years patients to 65 years old patients [20]. Alzheimer's disease is classified into familial and sporadic, which is also referred to as Late-Onset Alzheimer's Disease (LOAD). Familial is inherited and not affected by the environment. In LOAD, no gene has been identified as the cause of Alzheimer's disease [21]. However, some studies suggest that there could be a gene component found in LOAD. Apolipoprotein gene is often associated with sporadic LOAD. Yet, individuals with APOE were found to live before 90 years of age; this shows that there could be a different gene component that is associated with Alzheimer's disease.

### Clinical implication and impaction

Alzheimer's disease affects the quality of life of the patient as well as the people who take care of the patient. The health-care facilities that attempt to treat AD patients experience a strain on their resources [22,23]. Funds that would have been used to upgrade the facility's equipment are transferred for use in AD research. People with Alzheimer's disease frequently visit the health-care facility for treatment [24]. However, their health deteriorates with time as some of the patients may be involved in accidents. As the burden of caring for the patients' increases, many families prefer to send the patient to nursing homes to lower the psychological weight [25]. Facilities that handle Alzheimer's disease often experience an increase in the patient population.

### The unanswered questions

Even as various research studies are undertaken on Alzheimer's disease, there are many unclear and unanswered questions concerning the condition [26]. For instance, how can Alzheimer's disease be predicted or diagnosed? Are there genetic factors that contribute to the severity of the disease? Maki [27], in the study, queries if safe and efficient treatment exists for Alzheimer's disease? Why do highly effective clinical trials not show any positive impact on the treatment of Alzheimer's disease? How do brain cells loose function once the amyloid protein accumulates in the brain?

## Scientific Analysis

Over time, various scientific research studies have been done in an attempt to understand Alzheimer's disease [28]. Many characteristics are associated with Alzheimer's disease. Alzheimer's disease progresses in stages [29]. The steps include Mild Cognitive Impairment, bettering the diagnostic options. AD is believed by some researchers to be associated with some genetic components [30]. However, the causative gene has not been proved since some individuals carrying the gene survive past 90 years old [31]. The ability to discover the cure depends on a detailed view of various processes in the brain. The procedures could be cellular or molecular [32].

## Conclusion

In conclusion, the AD treatment can be advanced by surgery. The surgery can be done using a medical robot that incorporates an adaptive control system [11]. The system is detailed can result in a clear trajectory and navigation during surgery [33]. Alzheimer's disease is a neural disorder that presents specific symptoms such as memory loss during the early stages. However, as the disease advances, it offers more severe symptoms such as hallucinations [12,34]. Even though research has been done on the disease, there are many unanswered questions concerning the condition. There should be more detailed research associated with the genetics of Alzheimer's disease [35]. Also, research should be undertaken on highly effective treatment of the disease; this is because it is not genuinely useful yet approved by the FDA.

## References

1. Avgousti S, Christoforou EG, Panayides AS, Voskarides S, Novales C, et al. (2016) Medical telerobotic systems: Current status and future trends. BioMedical Engineering OnLine 15: 96.

2. Abedin Nasab MH (2009) Handbook of Robotic and Image-Guided Surgery. Elsevier Science, Netherlands.

3. Wang MY, Goto T, Tessitore E, Veeravagu A (2017) Introduction. Robotics in neurosurgery. Neurosurgical Focus 42: 1.

4. Burchiel K, Raslan A (2018) Functional Neurosurgery and Neuromodulation. Missouri: Elsevier Health Sciences, Amsterdam, Netherlands.

5. Bojan J, Gojko N, Darko C, Marko Š, Bojan Š (2015) Robotic application in neurosurgery using intelligent visual and haptic interaction. International Journal of Simulation Modelling 14: 71-84.

6. Davies B (2000) A review of robotics in surgery. Proc Inst Mech Eng H 214: 129-140.

7. Chumnanve S, Pillai BM, Suthakorn J (2019) Surgical Robotic Technology for Developing an Endonasal Endoscopic Transsphenoidal Surgery (EETS) Robotic System. The Open Neurology Journal 13: 96-106.

8. Castañeda LA, Juárez AL, Chairez I (2014) Robust Trajectory Tracking of a Delta Robot Through Adaptive Active Disturbance Rejection Control. IEEE Xplore digital library 23: 1387-1398.

9. Morimoto TK, Hawkes EW, Okamura AM (2017) Design of a compact actuation and control system for flexible medical robots. IEEE Robot Autom Lett 2: 1579-1585.

10. Romero LM (2019) Mediterranean conference on medical and biological engineering and computing . Springer, Switzerland.

11. Orsa RL, Macnab CB, Tavakoli M (2013) Introduction to Haptics for Neurosurgeons. Neurosurgery 72: 139-153.

12. Tcw J, Goate AM (2017) Genetics of β-amyloid precursor protein in Alzheimer's Disease. Cold Spring Harb Perspect Med7: 024539.

13. Desai JP, Agrawal SK, Ferreira A (2019) *Encyclopedia of medical robotics*. World Scientific Publishing Co. Pte. Ltd. Hackensack, Singapore.

14. Dombre E, Khalil W (2013) Robot Manipulators: Modeling, Performance Analysis and Control. HAL 448.

15. Kumar A, Singh A (2015) A review on Alzheimer's disease pathophysiology and its management: An update. *Pharmacol Rep67:* 195-203.

16. Fisher T, Hamed A, Vartholomeos P (2014) Intraoperative magnetic resonance imaging–conditional robotic devices for therapy and diagnosis. Proc Inst Mech Eng H 228: 303-318.

17. Haidegger T, Barreto M, Gonçalves P, Vaccarella A (2013) Applied ontologies and standards for service robots. Robotics and Autonomous Systems 61: 1215-1223.

18. Thal DR, Walter J, Saido TC, Fändrich M (2015) Neuropathology and biochemistry of Aβ and its aggregates in Alzheimer's disease. Acta neuropathol 129: 167-182.

19. Gomes P (2012) Medical Robotics 1st Edition Minimally Invasive Surgery. Woodhead Publishing, Cambridge, England.

20. Hoeckelmann M, Fiorini P, Rudas IJ (2015) Current Capabilities and Development Potential in Surgical Robotics. Intelligent and Robotic Systems 12: 1-18.

21. Jordanides T, Torby B (2012 ) *Expert Systems and Robotics*. NATO ASI Series, corfu, Greece.

22. Van Cauwenberghe C, Van Broeckhoven C, Sleegers K (2016) The genetic landscape of Alzheimer's disease: clinical implications and perspectives. Genetics in Medicine 18: 421-430.

23. Huang X, Rogers JT, Vanderburg CR, Barry L (2014) Metal Exposure and Alzheimer's Pathophysiology. Biochemistry & Pharmacology: Open Access 3: 1-2.

24. Chakrabarti S, Khemka VK, Banerjee A, Chatterjee G, Ganguly A, et al. (2015). Metabolic risk factors of sporadic Alzheimer's disease: Implications in the pathology, pathogenesis and treatment. Aging Dis 6: 282-299.

25. Kassahun Y, Tibebu BA, Giannarou DS, Poorten EV (2016) Surgical robotics beyond enhanced dexterity instrumentation: a survey of machine learning techniques and their role in intelligent and autonomous surgical actions. Int J Comput Assist Radiol Surg 11: 553-568.

26. Zhang D, Wei B (2017) Adaptive control for robotic manipulators. CRC Press, Boca Raton, USA.

27. Maki H (2017). Handbook of Research on Biomimetics and Biomedical Robotics. IGI Global, Pennsylvania, USA.

28. Peterson EC, Starke RM, Snelling BM, Menaker SA (2018) Current applications and future perspectives of robotics in cerebrovascular and endovascular neurosurgery. J Neurointerv Surg10: 78-82.

29. Efthymiou AG, Goate AM (2017) Late-onset Alzheimer's disease genetics implicates microglial pathways in disease risk. Mol Neurodegener 12: 43.

30. Yu H, Liu J, Liu L, Ju Z, Liu Y (2019) Intelligent robotics and applications: 12th International Conference, ICIRA 2019, Shenyang, China, August 8-11, 2019: proceedings. Part VI. Springer Nature Switzerland AG, Switzerland.

31. Tosun World Scientific (2010) Introduction to Surgical Robotics. Hackensack, USA.

32. Ortiz A, Munilla J, Gorriz JM, Ramirez J (2016) Ensembles of deep learning architectures for the early diagnosis of Alzheimer's disease. Int J Neural Syst 26: 1650025.

33. Tamburrini G, Ficuciello F, Siciliano B, Arezzo A, Villani L (2019) Autonomy in surgical robots and their meaningful human control. DE Gruyter 10:30-43.

34. Wang KJ, Sun M, Xia R, Mao ZH (2016) Human-Robot Symbiosis Framework on Exoskeleton. IEEE Taipei, Taiwan.

35. Sciavicco L, Siciliano B (2012) Modelling And Control of Robots Manipulators. Measurement Science and Technology 11: 12.

HERALD

Advances In Industrial Biotechnology | ISSN: 2639-5665

Advances In Microbiology Research | ISSN: 2689-694X

Archives Of Surgery And Surgical Education | ISSN: 2689-3126

Archives Of Urology

Archives Of Zoological Studies | ISSN: 2640-7779

Current Trends Medical And Biological Engineering

International Journal Of Case Reports And Therapeutic Studies | ISSN: 2689-310X

Journal Of Addiction & Addictive Disorders | ISSN: 2578-7276

Journal Of Agronomy & Agricultural Science | ISSN: 2689-8292

Journal Of AIDS Clinical Research & STDs | ISSN: 2572-7370

Journal Of Alcoholism Drug Abuse & Substance Dependence | ISSN: 2572-9594

Journal Of Allergy Disorders & Therapy | ISSN: 2470-749X

Journal Of Alternative Complementary & Integrative Medicine | ISSN: 2470-7562

Journal Of Alzheimers & Neurodegenerative Diseases | ISSN: 2572-9608

Journal Of Anesthesia & Clinical Care | ISSN: 2378-8879

Journal Of Angiology & Vascular Surgery | ISSN: 2572-7397

Journal Of Animal Research & Veterinary Science | ISSN: 2639-3751

Journal Of Aquaculture & Fisheries | ISSN: 2576-5523

Journal Of Atmospheric & Earth Sciences | ISSN: 2689-8780

Journal Of Biotech Research & Biochemistry

Journal Of Brain & Neuroscience Research

Journal Of Cancer Biology & Treatment | ISSN: 2470-7546

Journal Of Cardiology Study & Research | ISSN: 2640-768X

Journal Of Cell Biology & Cell Metabolism | ISSN: 2381-1943

Journal Of Clinical Dermatology & Therapy | ISSN: 2378-8771

Journal Of Clinical Immunology & Immunotherapy | ISSN: 2378-8844

Journal Of Clinical Studies & Medical Case Reports | ISSN: 2378-8801

Journal Of Community Medicine & Public Health Care | ISSN: 2381-1978

Journal Of Cytology & Tissue Biology | ISSN: 2378-9107

Journal Of Dairy Research & Technology | ISSN: 2688-9315

Journal Of Dentistry Oral Health & Cosmesis | ISSN: 2473-6783

Journal Of Diabetes & Metabolic Disorders | ISSN: 2381-201X

Journal Of Emergency Medicine Trauma & Surgical Care | ISSN: 2378-8798

Journal Of Environmental Science Current Research | ISSN: 2643-5020

Journal Of Food Science & Nutrition | ISSN: 2470-1076

Journal Of Forensic Legal & Investigative Sciences | ISSN: 2473-733X

Journal Of Gastroenterology & Hepatology Research | ISSN: 2574-2566

Journal Of Genetics & Genomic Sciences | ISSN: 2574-2485

Journal Of Gerontology & Geriatric Medicine | ISSN: 2381-8662

Journal Of Hematology Blood Transfusion & Disorders | ISSN: 2572-2999

Journal Of Hospice & Palliative Medical Care

Journal Of Human Endocrinology | ISSN: 2572-9640

Journal Of Infectious & Non Infectious Diseases | ISSN: 2381-8654

Journal Of Internal Medicine & Primary Healthcare | ISSN: 2574-2493

Journal Of Light & Laser Current Trends

Journal Of Medicine Study & Research | ISSN: 2639-5657

Journal Of Modern Chemical Sciences

Journal Of Nanotechnology Nanomedicine & Nanobiotechnology | ISSN: 2381-2044

Journal Of Neonatology & Clinical Pediatrics | ISSN: 2378-878X

Journal Of Nephrology & Renal Therapy | ISSN: 2473-7313

Journal Of Non Invasive Vascular Investigation | ISSN: 2572-7400

Journal Of Nuclear Medicine Radiology & Radiation Therapy | ISSN: 2572-7419

Journal Of Obesity & Weight Loss | ISSN: 2473-7372

Journal Of Ophthalmology & Clinical Research | ISSN: 2378-8887

Journal Of Orthopedic Research & Physiotherapy | ISSN: 2381-2052

Journal Of Otolaryngology Head & Neck Surgery | ISSN: 2573-010X

Journal Of Pathology Clinical & Medical Research

Journal Of Pharmacology Pharmaceutics & Pharmacovigilance | ISSN: 2639-5649

Journal Of Physical Medicine Rehabilitation & Disabilities | ISSN: 2381-8670

Journal Of Plant Science Current Research | ISSN: 2639-3743

Journal Of Practical & Professional Nursing | ISSN: 2639-5681

Journal Of Protein Research & Bioinformatics

Journal Of Psychiatry Depression & Anxiety | ISSN: 2573-0150

Journal Of Pulmonary Medicine & Respiratory Research | ISSN: 2573-0177

Journal Of Reproductive Medicine Gynaecology & Obstetrics | ISSN: 2574-2574

Journal Of Stem Cells Research Development & Therapy | ISSN: 2381-2060

Journal Of Surgery Current Trends & Innovations | ISSN: 2578-7284

Journal Of Toxicology Current Research | ISSN: 2639-3735

Journal Of Translational Science And Research

Journal Of Vaccines Research & Vaccination | ISSN: 2573-0193

Journal Of Virology & Antivirals

Sports Medicine And Injury Care Journal | ISSN: 2689-8829

Trends In Anatomy & Physiology | ISSN: 2640-7752