SOLARBOT:

How robotics may relieve OR physicians in 21st century

Artykuł recenzowany

Streszczenie

Proces starzenia się społeczeństwa skutkuje między innymi zwiększonym popytem na operacje chirurgiczne, w tym operacje małoinwazyjne z użyciem narzędzi laparoskopowych umożliwiających skrócenie niezbędnego czasu hospitalizacji. Operacja laparoskopowa wymaga, oprócz chirurga prowadzącego, również udziału asystentów odpowiedzialnych za nawigację kamerą laparoskopową oraz podtrzymywanie nieaktywnych narzędzi. Wprowadzanie technologii robotycznych umożliwia redukcję zarówno problemów w komunikacji między chirurgiem a asystentem, jak i możliwych błędów medycznych na skutek np. drżenia rąk oraz zmniejszenie kosztu procedury. Autor przedstawia w artykule rezultaty projektu prowadzonego w ramach grantu DIH-HERO, wykorzystującego technologię robotyczną ARIA/BATEO firmy ACCREA Engineering w zastosowaniu przy chirurgii małoinwazyjnej.

Abstract

The ageing of the population results, among other things, in an increased demand for surgical operations, including minimally invasive surgeries using laparoscopic instruments to reduce the necessary hospitalisation time. Laparoscopic surgery requires, in addition to the attending surgeon, the participation of assistants responsible for navigating the laparoscopic camera and supporting inactive instruments. The introduction of robotic technology makes it possible to reduce both the problems with communication between the surgeon and the assistant and the possible medical errors due to e.g. hand tremor, as well as reduces the cost of the procedure. The author presents the results of a project carried out under the DIH-HERO grant, using ACCREA Engineering's ARIA/BATEO robotic technology in minimally invasive surgery use-case.

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Keywords:
medical robots, minimally invasive surgery, endoscopy

PROBLEM

In the modern ageing societies, the demand for specialized medical care becomes higher, whereas a worldwide lack of physicians is observed. Forecasts warn that this lack will grow worse in the near future [actionforglobalhealth.eu]. Minimum invasive surgery (MIS) is rapidly growing, with 7.5Mn/year interventions worldwide, increasing this number and also broadening the interventions types.

Thanks to the specific approach, facilitating the use of specialized equipment designed to work inside the body cavities through one or more trocars, the surgery itself is especially beneficial for the patient, as causing less trauma, pain and blood loss, while leaving smaller skin scars, effectively reducing the duration of hospital stay.

MIS is typically performed by a surgeon with 1-2 assistants holding the camera, instruments, patient organs, etc. The assistant salaries increase the overall procedure cost and the need of managing the assistants (verbal communication, overlooking, control) is cumbersome for the surgeon. As some procedures may take longer to perform, the fatigue of additional supporting staff rises accordingly, increasing a risk of medical errors.

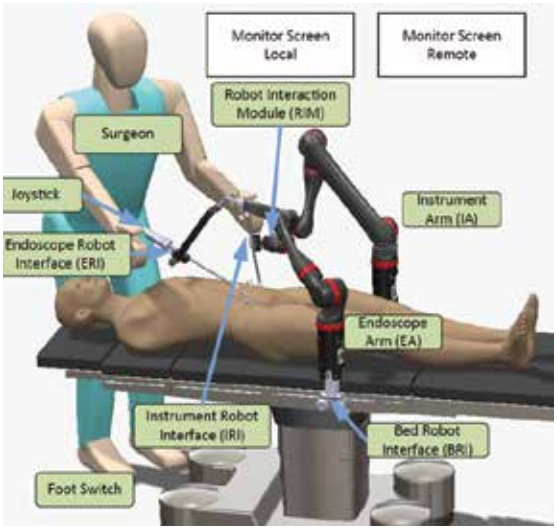
SOLUTION

Robot-assisted surgery is another alternative that can help out the surgeon who is a subject to tremor, fatigue etc.

Since 2019, ACCREA Engineering Poland has been developing an assistive robotic device aimed at helping minimal invasive surgeons by motorizing the movement of a laparoscopic camera around the trocar. The device is based on an off-the-shelf ARIA/BATEO robotic arm designed by ACCREA in the course of an R&D grant-based project L2R. In 2020 ACCREA had been granted funding from DIH-HERO, supporting the proposal aiming at demonstrating the feasibility of new, innovative and enhanced robotic solution in abovementioned field.

SYSTEM DESCRIPTION

The main system components are the Endoscope Arm EA, Instrument Arm IA, Local and Remote Screens. An Endoscope is connected to the EA using a dedicated Endoscope-Robot Interface ERI. The camera provides a live video stream presented on both Screens. The Local Screen is used by the Surgeon to view the operation scene inside the patient body. The Remote Screen is located in a different physical location, and serves the purposes of: i) remote consultations with another expert ii) training other surgeons remotely. The IA serves as a support of the instrument when not used by the surgeon, equipped with an Instrument-Robot Interface IRI



being able to quickly attach to an adapter fixed on each of the instruments. Both arms are equipped with control interfaces: i) Robot Interaction Module RIM for direct physical interaction (pushing and pulling the arms with the surgeon's hand) and also ii) by means of a joystick placed on the instrument or iii) voice control

IMPLEMENTATION & EVALUATION

During the course of SOLARBOT project, ACCREA successfully adapted their ARIA robotic arm technology to meet the requirements derived with assistance on project's Clinical Partner, Grosshadern Clinic of Ludwig Maximilian University of Munich.

The core of the system is a redundant, 7 Degree of Freedom arm with specialized end-effector suited for integration with a range of laparoscopic cameras and tools. The arm had been equipped with rail-mounting system to allow for a quick installation on the surgical table. Once in the OR, the device can be controlled by (i) hand, using a specialized Robot Interaction Module based on Force/Torque sensor; (ii) joystick, either simple 2DoF or Spacemouse, allowing for intuitive control of the end-effector point in all linear and rotational directions; (iii) voice control, around a virtually-assigned point in the trocar. Redundant kinematics gives the advantage of realigning the arm's structure not to obstruct the physician's field-of-view, while maintaining stable position of the camera or tool.

The main device is supported by a range of possible auxiliary arms: a half-motorized, half-passive redundant arm, 6DoF arm with a 3-finger gripper, gravity-compensated brake-based passive arm and redundant brake-based passive arm.

The verification and validation of the results were conducted during two stationary trials:

1) Szpital na Klinach Living Lab – June 4th 2021, Kraków, PL

2) Klinikum Großhadern of the Ludwig Maximilian University of Munich – June 23rd-24th 2021, Munich, DE

Both trials were led by Prof. Dr. med. Konrad Karcz, Head of Minimally Invasive, Robot-Assisted Surgery and Surgical Technological Innovations at LMU Munich and a Medical Consultant for Solarbot project.

First round focused mostly on testing additional equipment – interfaces responsible for integration with the surgical table and with camera and tools, and overall preparation procedures. Robot Interaction Module was used to preposition the arm over the phantom, while 6DoF joystick acted as an interface to facilitate more precise movement.

The second round aimed at presenting and testing the overall workflow during minimally invasive surgery. The system containing two robotic arms was decontaminated and suited with sterile drapes. Both devices were then integrated with surgical table, on left and right side of the medical phantom of the human abdomen. Just like during first testing round, both arms were initially positioned to be connected with surgical equipment – white 7DoF arm was used to navigate the camera (mounted on the arm via Endoscope-Robot Interface), while black arm was holding either unused laparoscopic tools or a magnet used for externally controlling the position of an intestine-holding metal clip. The leading surgeon then performed a model laparoscopic procedure in the phantom abdomen, facilitating the functionalities of the system.

SUMMARY & ACKNOWLEDGEMENTS

The segment of the healthcare market related to Minimally Invasive Surgeries is rich with different devices tackling the problem of inefficient assistant's role during MIS procedures, however currently available products don't approach this issue globally but rather locally, where to hold the camera and additional instruments operators need multiple devices from different companies. Therefore, there is a gap on the market for a holistic, multipurpose robotic system tackling all desired use-cases at once. ACCREA attempts to fill this gap by introducing SOLARBOT system containing multiple, compatible robotic devices to be used during MIS, each one designed to work with both camera and instrument holding use-cases.

Validation trials had shown that the idea behind the system proves to be applicable in laboratory conditions, with possible introduction to real-life environment and ultimately to market.

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KOMENTARZ RECENZENTA...

Prof. Zbigniew Paszenda

Zastosowanie technik małoinwazyjnych znajduje coraz większe zastosowanie w różnych dziedzinach medycyny. Stosowanie tego rodzaju technik wymaga, oprócz chirurga prowadzącego, dodatkowo udziału osób asystujących odpowiedzialnych za nawigację kamerą laparoskopową oraz podtrzymywanie nieaktywnych narzędzi. W pracy przedstawiono wyniki testów realizowanych w ramach projektu DIH-HERO' w którym wykorzystano technologię robotyczną ARIA/BATEO firmy ACCREA Engineering w odniesieniu do chirurgii małoinwazyjnej. Zaproponowany system SOLARBOT zawiera szereg kompatybilnych urządzeń zrobotyzowanych do użycia podczas tego rodzaju zabiegów z których każde jest zaprojektowane do pracy zarówno z aparatami, jak i uchwytami narzędzi. Przeprowadzone testy w warunkach laboratoryjnych potwierdziły przydatność analizowanego systemu do zastosowań w chirurgii małoinwazyjnej.