# Telesurgery PIC

## 1NC – OFF (Short)

PIC – Telesurgery

#### Plan: The United States federal government should implement a single-payer universal healthcare system for all telehealth services except telesurgery.

#### Telesurgery useless and fails – latency, personnel and cost requirements.

Choi et al. 18 (Paul J. Choi, Rod J. Oskouian, and R. Shane Tubbs, Surgery, Seattle Science Foundation, Seattle, USA, Neurosurgery, Swedish Neuroscience Institute, Seattle, USA, Neurosurgery, Seattle Science Foundation, Seattle, USA, May 2018, accessed on 9-11-2022, PubMed Central (PMC), "Telesurgery: Past, Present, and Future", https://www.ncbi.nlm.nih.gov/pmc/articles/PMC6067812/) //phs st

In 2014, Shenai et al. introduced Virtual Interactive Presence (VIP), a novel technology that allows remote neurosurgeons to collaborate with a shared 3-Dimensional (3D) display via high-definition binoculars [5,10]. This real-time visual system allows the surgeons to view a merged surgical field display of each other’s hand motions [5]. Shenai et al. carried out successful pterional and suboccipital craniotomies and microscopic approaches to the pineal gland on a cadaveric model using VIP [5,10]. Therefore, VIP would not only be applicable in surgical patient care but would also be useful in surgical training since it allows for a profound real-time interaction among surgeons at different medical centers from around the world [3,10]. However, VIP has a drawback of having a mean latency-time of 760 ± 606 milliseconds, thus further optimization is required [5].

Studying the latency time

A major problem with telesurgery is latency time, which is defined as the time delay in transferring auditory, visual, and even tactile feedback between the two distant locations [1]. Increased latency time is mainly attributable to network routing problem and congestion, and server overload. The time delay not only generates a lengthy operation but also produces significant surgical inaccuracy [7-8,14], which can risk the safety and delay the recovery of the patient [1,3,7].

According to Wirz et al., an ideal latency time is less than 100 milliseconds and a latency time that is greater than 300 milliseconds produces major inaccuracies in instrument handling [15]. In fact, the first telesurgical cholecystectomy conducted in 2001 had a latency time of 155 milliseconds [7]. Further, a Da Vinci (Intuitive Surgical, Sunnyvale, CA, USA) prototype was used by Nguan et al. in 2008 to check its feasibility in a telesurgical application [14]. However, the prototype produced 340 milliseconds of latency time [14]. Moreover, National Aeronautics and Space Administration (NASA) has conducted experiments in the areas of televascular surgery such as laparoscopic cholecystectomy and abdominal surgery for astronauts [1]. However, a significant time latency is also an issue here [1]. Korte et al. concluded that even the most experienced teleoperator cannot perform with acceptable accuracy and efficiency when the latency time is greater than two seconds, further emphasizing the significance of this variable in telesurgery [7].

Although a latency time of less than 100 milliseconds can be achieved with today’s high-speed fiber optic cables and a dedicated asynchronous transfer mode (ATM), 40 technicians must be present during the surgery to maintain this speed [1,5,8,16]. Interestingly, Xu et al. studied the effects of latency time training and claimed that a degree of inaccuracy from a time delay can be overcome via training the teleoperator [8].

Introduction of haptic feedback technology

The conventional telesurgery system had a major drawback in that it failed to provide tactile information and the operator solely relied on a visual feedback [17]. The technology that enables transmission of tactile information to the teleoperator is termed "haptic feedback." This is a crucial aspect of a wireless robotic surgical system, which enables the operator to feel the consistency of the tissue and the tension within the sutures, prevents damage to the fragile tissues or tearing of the sutures during the operation, and improves the operator’s confidence during surgery [12,17-18].

The first telesurgery prototype that implemented haptic feedback technology was Telelap Alf-x (SOFAR S.p.A., ALF-X Surgical Robotics Department, Trezzano Rosa, Milan, Italy), which was introduced in 2015 [18]. Telelap Alf-x, by providing a haptic feedback to the surgeon, successfully reduced the average time of experimental cholecystectomy by 60 minutes [12,17-18]. This system was also equipped with an eye-tracking technology, which halts the movements of the robotic arms when the operator’s eyes are not fixed on the screen [12,17-18] and provided an added cost-effectiveness by using low-cost reusable parts [12,18]. In 2017, Su et al. presented a new MRI-guided telesurgery system that performs percutaneous interventions and provides haptic feedback to the operator using varying degrees of pneumatic pressure [19].

Emerging telesurgical technologies

Although in its infancy, tele-neurosurgical technology is currently being explored. In 2007, O’Malley and Weinstein conducted a successful cadaveric skull base surgery using a trans-oral approach [6,20]. And about a decade later, Wirz et al. presented an endonasal feasibility study for trans-sphenoidal resection of a pituitary tumor with 10 milliseconds of latency time, with the surgeons agreeing that using the device did not feel significantly different from handling a conventional endoscope [16].

Zhao et al. recently published a feasibility study of the integration of a floating 3D visual feedback system in telesurgery [9]. This integration allows multiple surgeons to see a floating, holographic image of the surgical field simultaneously, enhancing the detail of the shared visual display and real-time collaborations amongst medical professionals across the border [9].

Current limitations of telesurgery's clinical translation

Despite the introduction of numerous telesurgical innovations since 2001, only a single randomized controlled telesurgery trial of percutaneous access of the kidney with a remote center of motion active robotic device (PAKY-RCM) exists to date [1]. In addition to the need for further optimization of visual display, latency time, and haptic feedback technology, further randomized controlled trials should be performed to lead to the innovations’ successful clinical translation [17-18]. Other main factors that prevent the implementation of telesurgical technology into today’s clinical setting are summarized in Table ​Table2.2. If such limiting factors are not dealt with prior to launching the clinical use of this technology, malpractice, the inefficiency of care, and unnecessary spending may result [4].

Table 2

A summary of factors that currently limit the use of telesurgery in the real world

Factors that limit Telesurgery’s Clinical Translation

Lack of fully developed training programs and standard operating protocols (including that for equipment maintenance)

The difficulty of the acquisition of equipment

Need for development of a global network

Billing issue on distributing operation fee and facility fee among the participating medical centers

Funding issues

Legal issues, which vary across state and country borders

## 1NC – OFF (Long)

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#### Hacking kills telehealth and causes legal issues – newest tech isn’t enough.

Koon 22 (John Koon, John Koon is a contributing editor at Semiconductor Engineering., 6-30-2022, accessed on 9-11-2022, Semiconductor Engineering, "Risks Rise As Robotic Surgery Goes Mainstream", https://semiengineering.com/risks-rise-as-robotic-surgery-goes-mainstream/) //phs st

As robotic-assisted surgery moves into the mainstream, so do concerns about security breaches, latency, and system performance. In the operating room, every second is critical, and technology failures or delays can be life-threatening.

Robotic-assisted surgery (RAS) has around for a couple decades, but it is becoming more prevalent and significantly more complex. The technology often includes a variety of processing elements and sensors, built on architectures capable of crunching massive amounts of data and providing real-time feedback to surgeons and their support teams. But these machines also are increasingly connected to the internet — either directly or through some other network — and this is where many problems begin.

“Robotic surgery systems have developed into a mainstream tool for hospitals. They allow for more precision and less-invasive operations, exceeding the capabilities of traditional surgery, said Marc Witteman, CEO of Riscure. “But as with all connected devices there is a security risk, which has recently become apparent in the many ransomware attacks. Imagine that your urgent medical procedure halts due to a hacker-invoked system crash. Or even more advanced, suppose the procedure is hijacked and deliberately made to mal-perform.”

While much of this equipment is still used for on-site surgeries, it can be used remotely.

“This is where 5G comes into play,” Witteman said. “This technology offers low latency and high reliability and is suitable to remotely control RAS. But while 5G technology is designed for security, this covers only part of the risk. Indeed, a strong design mitigates attacks that exploit limitations of the technology, but an even bigger threat is in the implementation. Embedded systems software is increasingly complex, and we know that devices typically contain hundreds of vulnerabilities. There are weaknesses in the product that do not impede normal operation. However, an attacker who knows those weaknesses, and who can combine them for malicious ends, can exploit them.”

Those breaches also raise privacy concerns, and the less secure the networks — which is a problem with surgeries performed remotely for rural areas — the greater those concerns.

“The confidentiality and integrity of crucial control and telemetry signals sent over a network link should always be protected with strong end-to-end mutual authentication between devices,” said Mark Knight, director, architecture product management at Arm. “To implement this, the robot and the remote doctor’s controller should have strong, secret credentials protected within a hardware root of trust. A root of trust provides trusted functions that higher-level device services can use to ensure security. Security frameworks and certification programs, such as PSA Certified, can offer a standardized approach to security, allowing the entire value chain to work with consistent requirements to implement security measures that are right-sized for the use case. Widely deployed network transport protocols such as TLS can then use the secured credentials to underpin device-to-device authentication, helping to mitigate the risk that control signals are intercepted or modified.”

Yet even day-to-day interruptions can cause issues. Service fluctuations can bring a surgery to a halt, and operations that are performed remotely may be impacted by everything from weather to geopolitics. Because this is still relatively new, regulations and best practices will take time for formulate.

“There are challenges with remote surgery,” said Sathish Balasubramanian, head of products at Siemens EDA. “Many of the surgical procedures require high precision. Local robotic-assisted surgery provides that benefit. However, remote surgery depends on a highly reliable network with high bandwidth and low latency. During the operation, especially with a 3D vision support, a delay of 4 to 5 seconds is like an eternity and may be critical to the success of the operation. Additionally, the FDA still needs to address some of the open issues. During the remote operation, if the lead doctor with full qualifications is not present in the operating room, how will the FDA regulate that? If something goes wrong, who would be responsible? The lead doctor who performed the operation remotely, the assistant doctors in the operating room, or the manufacturer of the surgical equipment?”

RAS origins

In the 1970s, NASA came up with the idea of doing surgery remotely. Thirty years later, robotic-assisted surgery (RAS) started to enter the field of medicine. On September 2, 2001, a group of French doctors in New York operated on a patient located in Strasbourg, France, using the Zeus surgical robot. Called the Lindbergh operation, it was the first successful telesurgery procedure to remove the gallbladder from a patient.

#### Data shows distrust.

McDermott et al. 22 (Hilary McDermott, Nazmin Choudhury, Molly Lewin-Runacres, Ismail Aemn, and Esther Moss, School of Sport, Exercise and Health Sciences, Loughborough University, Loughborough, Leicestershire LE11 3TU UK, School of Sport, Exercise and Health Sciences, Loughborough University, Loughborough, Leicestershire LE11 3TU UK, School of Sport, Exercise and Health Sciences, Loughborough University, Loughborough, Leicestershire LE11 3TU UK, Department of Gynaecological Oncology, University Hospitals of Leicester, Leicester, Leicestershire UK, 2Department of Gynaecological Oncology, University Hospitals of Leicester, Leicester, Leicestershire UK3Leicester Cancer Research Centre, University of Leicester, Leicester, LE2 7LX UK, 5-2-2022, accessed on 9-11-2022, PubMed Central (PMC), "Gender differences in understanding and acceptance of robot-assisted surgery", https://www.ncbi.nlm.nih.gov/pmc/articles/PMC7000495/) //phs st

Research has also identified that the perceptions of robotic surgery among surgical patients and medical staff often do not accurately reflect the real-world situation [1] and there is widespread misunderstanding of the role of the robot [7]. Boys et al. [7] reported that 67% of their participants thought the robot could malfunction during surgery thus causing internal damage to the patient, 15% thought the robot could perform the wrong operation and 55% reported that they would rather have the conventional minimally invasive surgery rather than having robotic surgery. Participants also displayed misperceptions about the role of the surgeon with 20% believing that the surgeon would stand and watch over whilst the robot carried out the procedure with its autonomous function. Boys’s study was one of the first to focus on the perceptions of robot-assisted surgery among the general public and utilised a web-based survey. However, 94% of respondents were from the United States and over half (53%) had a background in health care and 13% were physicians [7]. It is, therefore, apparent that further studies are needed to fully understand public interest and perception in relation with robot-assisted surgery.

#### Telesurgery causes distrust of doctors that spills over.

Perumal 21 (Neha Perumal, WUSTL journalist, 11-28-2021, accessed on 9-11-2022, Frontiersmag.wustl, "Legal and Ethical Considerations of Robotic-Assisted Surgeries – Frontiers", http://frontiersmag.wustl.edu/2021/11/28/legal-and-ethical-considerations-of-robotic-assisted-surgeries/) //phs st

The patient-physician relationship could also become degraded if robotic-assisted surgery becomes more commonplace in the medical field, and the implications of this degradation could change medical outcomes in the long run. Currently, the da Vinci robot has been installed in just over 1,700 medical facilities globally and has served around 775,000 patients [8]. Considering the machine’s high price tag of 2 million US dollars that puts it out of budget for most medical facilities, da Vinci procedures have been done on a very large number of people with only a 0.179% patient injury rate between 2000 and 2013 [7] and an 80-88% overall patient satisfaction rating [6]. Statistically speaking, robotic-assisted surgery seems to be a favorable procedure for patients in the short term. Nevertheless, these data do not speak for the long-term social implications of these procedures. One study done to assess gender differences in the acceptance of robotic-assisted surgery, it was found that many female subjects were concerned about the “doctor–patient relationship” aspect and considered it “an essential aspect of patient care prior to undergoing an operation” [5]. Many of the male subjects were not concerned with the lack of direct doctor-patient interaction during robotic-assisted surgery, but that is not to say this is not an important facet of patient care for everyone [5]. These interpersonal relationships are very important to consider, especially since the Duke Center for Personalized Care has found that “Effective physician-patient communication…positively influence health outcomes” through “better adherence to treatment plans” and building overall trust and communication [4]. So, while da Vinci procedures have shown to be safe and effective surgical techniques, if they become the industry standard, there may be decline in the efficacy of general medical care.

Robotic surgery has made strides for medical research and advancement, and there is still a long way to go before these procedures become commonplace in healthcare facilities. Still, as progress is being made toward that goal, it is important to stop and consider the side effects of rapid innovation. While technology can mitigate risks of certain medical procedures and shorten recovery time, these benefits should always be considered alongside the disadvantages and drawbacks. In the case of robotic-assisted surgery, there are already legal and ethical concerns regarding training and informed consent. As innovation drives robotic surgery to automation, how will these concerns grow and how will the patient-physician relationship further deteriorate? Innovation often obscures its flaws, but if care is taken to fully consider all these factors together, medicine can move forward into the future in a safe and positive manner.

### Card 1

https://www.ncbi.nlm.nih.gov/pmc/articles/PMC6067812/

### Card 2

RECENTLY, medical teleoperation systems involving two distant master and slave robots through the Internet or other Internet protocol (IP)-based wide area networks have become an emerging technology. As an example, telesurgical robotics systems (TRSs) where the master (surgeon controller) interacts with the slave (surgical robot) placed in a remote geographical location have revolutionized minimally invasive surgical procedures [1]. The world’s first telerobotic surgery over the public Internet was performed in 2003, and since then, several hundred more have been performed [2]. The next generation of surgical telerobotics systems, including portable TRS, is envisioned to provide medical relief in the areas of natural disasters and battlefield environments [3]. The European Space Agency has initiated experiments with telerobotic imaging for potential use in its space program. Researchers have proposed a master–slave-type remote ultrasound diagnostic system for acquisition and transmission of diagnostic images [4], [5]. Position, orientation, and the contact force between the ultrasound probe and the affected area of the patient are controlled through the communication network. A major problem that can be found in these medical teleoperation systems is time delay. In teleoperation over Internet, the originally delay issue, essentially confined to the time constant case, is moved toward time-varying delay [6]. While control theory for bilateral teleoperation systems under constant time delay is well developed, the research on time-varying communication delay is still ongoing [7], [8]. Standard control architectures for bilateral teleoperation systems are based on the scattering theory formalism [9] and subsequently reformulated using wave variables [10], [11] or controller passivity [12]. The situation becomes more complicated when the communication channel has intermittent transmissions as well as random delays. These problems can be neglected, where quality of service (QoS) guarantees can be made, such as with asynchronous transfer mode networks. However, IP-based networks are the main alternatives for use in teleoperation systems, and the delay varies with congestion, bandwidth, and distance, leading to values of several tens of seconds [13]. TRS needs reliable and performant transport protocols to guarantee a certain level of QoS [14]. As a result, bilateral teleoperator performances may severely degrade, and instability may also arise, if random communication delays are not controlled. Recently, advanced control methods proposed in the field of networked teleoperation, including gain scheduling, Markov jump linear systems [6], event-based approaches [15], discrete time passivity [16], and linear matrix inequalities, consider networks with packet loss and varying bounded delays [17]. In such TRS systems, a relevant but more serious issue is network attacks, such as denial of service (DoS), compromise in integrity, as well as information disclosure in data exchange. To securely transmit sensitive data, e.g., force and position feedback in TRS systems, across the Internet network, bilateral controllers need thus to ensure stability/performance criteria while preventing potential network attacks. These attacks are a real problem because they have been proven capable of shutting off a teleoperated system from the Internet or dramatically slowing down network links [18], [19]. For example, in classical DoS attacks, malicious users send a large number of SYN flooding packets or any other spurious packets to a destination to consume excessive amounts of endpoint network bandwidth. Moreover, packet delay, jitter, and loss become worse under these kind of attacks, which, in turn, may significantly impair the teleoperation performance such as percentage overshoot, rise and settling times, and mean square error [13]. Simultaneously supporting security and timing constraints is challenging, since these requirements can compete for computational resources. In fact, security support generally causes missed deadlines or unacceptable QoS degradation. Although cryptographic security and real-time network-based teleoperation systems have been well studied separately, very few works have been done to meet both QoS optimization and security constraints. It is therefore important to consider both security and QoS together when designing protocols for Internet-based bilateral teleoperation [20]. We have proposed a predictive controller in the discrete time domain to solve control problems of bilateral teleoperation over the Internet [21]. The major advantages of model predictive control (MPC) are the possibility to handle constraints and the intrinsic ability to compensate large and poorly known time delays. Stability conditions of the nominal overall system for constant and timevarying transmission delays are based on a frequency-domain approach. Hereafter, we secure our application, and we report an experimental investigation to 1) ensure QoS of real-time teleoperation tasks, 2) avoid potential deadline misses due to increased security cost, and 3) ensure security services such as access control, data origin authentication, antireply integrity, connectionless integrity, and data confidentiality. In this context, the QoS-friendly IP security protocol (IPSec) framework [19] could be a good candidate as it is the de facto standard for IP network security (knowing that our teleoperation system is an IP-based network). However, IPSec prevents network control devices from providing preferred treatment for timecritical applications such as medical telerobotics. In fact, for security and confidentiality reasons, IPSec encrypts data needed for classification. Performing QoS is thus impossible while applying classical security mechanisms such as IPSec. To solve this problem, we propose a new security protocol, namely, Q-IPSec, and we apply it to our Internet-based bilateral teleoperation system to provide both security and QoS supports. The experiments demonstrate that our protocol prevents network attacks while enhancing the throughput and reducing the packet loss, the latency, and the jitter. The remainder of this paper is organized as follows. Section II briefly introduces the networkbased teleoperation system. After that, Section III describes the specific bilateral generalized predictive controller design. Then, Section IV outlines our first solution based on packet loss management. Afterward, Section V analyzes the robustness of our teleoperation system under DoS attacks and presents a new solution based on Q-IPSec. Section VI presents our experimental investigations based on security and QoS metrics such as jitter, latency, throughput, and packet loss. Section VII discusses some related works, and finally, Section VIII draws up our conclusions and future works. II. NETWORK-BASED TELEOPERATION SYSTEM DESCRIPTION Our first aim in this paper is to study how network security failures may affect network-based teleoperation systems. The considered system layout is described in Fig. 1. This master–slave bilateral teleoperation structure allows a human operator to drive a slave robot in contact with the external environment. The contact forces are reflected to the human operator via the master haptic device. The system structure is composed of several modules that exchange data in real time through the Internet. The master and slave systems are two 6-degree of freedom (DOF) haptic devices PHANTOM Omni. The master stylus is handled by the operator, and the slave stylus is free. In the proposed application, only the translation of the force (newton) and of the position (meter) on the Z-axis (1 DOF) can be measured and controlled. The virtual touch software Handshake proSENSE provides blocks that generate various haptic effects at the end effector of the haptic device. This software allows the PHANTOM’s mass–spring–damper connection for the drag forces (km = ks = 20 N/m, bm = bs = 3 Ns/m, mm = ms = 50 g). The Host and Target computers are PC running Simulink models in the real-time Handshake proSENSE environment. These computers establish the connection between the two sides via the Internet. The Host computer contains the predictive RST controller (4) implemented under MATLAB/Simulink. Moreover, the Host computer collects and saves all exchanged data. The Target computer simulates a virtual linear external environment in contact with the slave stylus in the Simulink model. To avoid the saturation of the phantom (femax = 3.3 N), the virtual external environment is considered with a weak stiffness gain (ke = 10 N/m).

### Card 3

The limitations of telesurgery

Telesurgery is not without limitations, however. There are considerations towards patient safety and privacy, high costs of initial implementation and maintenance, as well as legal and ethical concerns.

Privacy, particularly when sensitive images of patient data are transferred through the internet is of utmost priority, however, cyber-attacks and unstable connections may complicate the ability to carry out telesurgery safely and ethically. Latency may also result from an unstable connection which can increase the chance of inaccuracy during the surgical procedure as well as extend the operation time.

Disadvantages of telemedicine include confusion for patients regarding the identity of their physician or extended healthcare team, in the absence of standard operating procedures. This may additionally complicate patient consent to telesurgical procedures.

The COVID-19 pandemic has highlighted a more recent and emerging problem in telesurgery; health inequality that disproportionately affects people of lower socioeconomic status and higher age categories. This is because many people from these groups do not meet prerequisites; a National Health Service digital figure showed that approximately 40% of people did not have access to online consultations in any form in 2019. Advancing telemedical technology is likely to widen inequity between those who are able and unable to access adequate healthcare.