

Robot surgeon at the hospital without medical physics

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ABSTRACT

If you have a surgical robot, it is without human presence, ready to safely give yourself to him? Even if you are in charge of anesthesia is a robot, what would you feel? Well, apparently it was a brave man who lets the robot for the first time, the full operation without human presence on him to do. The McGill University Health Centre, two robots and Vinci, the world's first robotic surgery to remove the prostate, a man, did. Vinci surgical robot that surgeons may be useful (or maybe I should say her) remote control. Is in fact an anesthesiologist. The two robots working together in the General Hospital of Montreal's first robotic surgery was successful. The surgeons them closely. Three-dimensional images Vinci surgical team sent to them via video monitor, arm used. Also proved to be very good with the robot for surgeons. Anesthesia in a surgical robot can be difficult because the patient must be in a constant state of muscles altogether. It is said that for every operation can come to a good anesthesiologist, the patient's level of consciousness control. Current technology that is a main focus of hospitals today. Whether the hospitals are installing them for the time saving aspect or whether they are installing them to help cut cost of the hospital, they are all helping the hospital to become more efficient than it was before the robots were installed. Once hospitals all around see the many great benefits of courier robots, they will have a tough decision to pass on the autonomous machines. More and more hospitals are continuing to install these robots and are embracing the many benefits they are bringing. Although courier robots are not necessarily a new piece of technology on their own, they have just recently become technologically advanced enough to earn their rightful place in hospitals. The robots today are capable of saving time and money, two of the most important things for any business, especially a hospital. As more and more improvements are made on courier robots, hospitals will begin to employ more. Courier robots will play a vital role in the future of hospitals and health care facilities around the world. These autonomous robots are extremely efficient and serve a priceless service to hospitals across the world.

KEY WORDS: Robot, surgeon, hospital, medical, physics

1. INTRODUCTION

There has been a quiet revolution in robotics taking place over the last decade or so. Robots have been moving from research labs and factory floors into places that are inhabited by ordinary people. As the service robot industry continues to seek new opportunities that generate value in people's lives, homes and workplaces there is a pressing need to design robots whose behaviour people can understand and predict. Human-robot interaction and social robotics are fast becoming hot research topics in the field of robotics as researchers frantically seek and develop new scientific methods to assist in the design of complex human-robot interactions and collaborations. The trend in robotics sees robots taking on increasingly expansive roles as slave, companion and collaborator. A new challenge for social robot design is to create robots that enact behaviour that people can anticipate; because when people work closely with robots they must be able to predict how a robot will react to some degree in order to undertake cooperative action.

Robots are real-time computer systems that can chose to undertake physical work. Robots essentially use, the so-called, classical sense-think-act processing cycle to perform selected actions usually based on their knowledge, know-how and perceptions. Robot designers determine how a robot will choose its next action: autonomous robots spend their entire life trying to make sense of their world and choosing the next action to execute and enact.

This paper takes a decision-theoretic stance on robot action selection using ideas from behavioural choice theory and bounded rationality to explore a new approach to robot behaviour design that can be used to develop robots that people can predict and that can interact and collaborate with people in reasonable and rational ways. Section 2 describes state-of-the-art in robot design. Section 3 the importance of people being able to interpret and predict robot behaviour. Section 4 introduces choice theory as a tool for describing and analysing the robot action choice problem, and explores the idea of what it would mean for a robot to act reasonably or rationally. The paper closes in Section 5 with a discussion of how choice theory can be used to advance the field of social robotics.

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The overall objectives:

Robot surgeon at the hospital without medical physics time consuming tasks? What if a nurse could spend most of his/her time with the doctors and patients? What if there was a way for all of these tasks to be completed without the nurses or doctors having to spend their time to complete them? Nurses would be able to perform the more important tasks and would be able to spend much of their time helping to comfort the patients. Courier robots are the answer. These high tech, autonomous machines are able to perform the routine tasks that nurses carry out every day. Courier robots can help make a hospital become more efficient in many ways. These robots can carry out the responsibilities of the nurses and allow the nurses to comfort the patients. These autonomous robots can bring countless benefits to hospitals, nurses, and patients. By employing courier robots into hospitals, hospitals would save time and money and would ultimately become more economically efficient.

2. MATERIAL AND METHODOLOGY

Courier robots are an innovative, new, and helpful technology that some hospitals are implementing to increase efficiency. There are many different types of courier robots in hospitals and they all do different things. Some types of courier robots are more productive and are more technically advanced than others, but they all have the same goal of performing simple tasks to free up time for the nurses. One of the simpler types of courier robots is the RoboCart. It is a motorized table that looks like a four foot cabinet with flashing lights and turn signals. This type of courier robot has a fixed path set up by tape placed in a hallway. It travels along the tape and has sonar built in to help it avoid smacking into a person or object in its path. Its main goal is to carry blood samples from one end of the laboratory to the other [1].

One advanced type of courier robots is the TUG [2]. This type of robot can actually tell the difference between a person standing in its way and a bag that is placed in the hallway. The TUG uses wireless radios to call elevators and to open automatic doors. The robot is full of detailed maps of the hospitals and full of computer programs to help them keep track of where they are and where they are going [1]. The TUG robot can talk, and it will ask people to stand aside if they are in its way and respond with a, “thank you,” after it makes a successful delivery. The TUG robot and some others have cabinets that can be mechanically and electronically locked so that they keep the supplies and information they are storing safe. The TUG robot mostly is made up of ultrasonic sonar’s, infrared, and laser range finders that help it to navigate and avoid obstacles [3]. It weighs about 55 pounds and consists of a drive train of two independent 24VDC motors, a body of abrasion-resistant ABS plastic, a power system, and high traction wheels which allow it to travel [4]. A TUG robot starts its rounds when a nurse or doctor calls on it with a touchpad. They are able to choose which unit, where it will go, and what supplies it will carry. When the robot arrives, the nurse punches in a code to open the locked drawer. Once the supplies have been delivered, the TUG robot then navigates back to its dock to charge until another delivery is ready to be made [5].

There are many types of courier robots that are being implemented in hospitals. The TUG and the RoboCart are just a two of the many types in existence. They all have the same goal to carry out the chores and deliveries that a nurse normally would make. They are giving nurses the opportunity to give patients the human interaction that is most important in hospitals. While nurses would usually be running back and forth gathering supplies, they are instead able to talk and interact with the doctors and patients while the robots are the ones traveling back and forth to gather the needed supplies. These robots are making the hospitals more efficient by saving the nurses’ time and possibly eliminating errors which could have been made by a nurse. The goals of these courier robots have been proven successful among many hospitals already and those hospitals are more efficient now than ever. Courier robots are going to save many hospitals time and will eventually end up saving them money as well.



Figure 1: Robots in Surgery

Courier robots weren't always what they were today. In fact, some of the earlier versions were very unsuccessful. But every failed trail helped to lead to the innovative and autonomous technology we consider to be courier robots today.

The first most basic version of a 'courier robot' was assembled in 1992. It was called the Astrobot and employed many of the basic principles that courier robots today contain. The Astrobot could take verbal commands and avoid large objects in its way. Besides this, the machine was just a pile of gears [6].

The next major version of a courier robot to be released on the market was the HelpMate robot. This version was a very big improvement on the older courier robots. This was one of the first robots to actually be used in hospitals. The older versions of the robots were too insufficient to even be implemented in hospitals. These HelpMate robots were able to load supplies and transfer the equipment to wherever they were called. For the robots to move, the hospital had to lay magnetic tape on the floor which was the only path the robot was able to follow. They were not able to call elevators or open doors on their own. On another downside, these HelpMate robots were very bulky and people often had a problem getting around them in hallways [7].

Back in 2004, the RoboCart was released into hospitals. This robot most closely resembles the TUG robot and courier robots in hospitals today. It was described as looking like, "a vacuum cleaner mated to a cabinet." This robot was able to navigate halls with a little more ease than the HelpMate but still required the magnetic strip on the ground. It was able to carry x-rays, prescriptions, and many other hospital items that needed to be transported to and from various locations. Back then, the robot could make about 30 trips a day. The RoboCart was also able to talk in English as well as Spanish, so it was the first bilingual courier robot to be introduced into hospitals [8].

Finally, the TUG robot (in its newest form) at 2012. The TUG robot is everything a courier robot should be. It works almost entirely on its own, it speeds up processes, and it saves the hospital money. It needs no tape to follow due to its very advanced sensors. It is compact and can lock its drawers to help keep documentation private. It truly is the best hospital courier robot to ever be invented [9].

From broken bones to sicknesses to heart problems, there are millions of reasons why someone might end up in a hospital. And with all these reasons to take a trip to the hospital, there are plenty of people that visit hospitals every single day. So many, in fact, that wait times have increased dramatically. Since 2002, the average wait time for Emergency Departments (ED) has increased by over half an hour [10]. The increased wait time has even lead to some terrible results.

A few years ago, a 49-year-old woman visited the ER with chest pains. After waiting for over two hours, Beatrice collapsed on the floor. And although doctors rushed to her side, it was too late, and unfortunately, she passed away. If the wait time was compressed, things may have been different for Beatrice and she may still be alive today [11].

Although Beatrice's story is tragic, it does stand to prove a good point: hospital wait times *need* to be reduced. Although many speculate on different methods to improve these times, the courier robot is a viable choice and has actually already been implemented in some facilities around the world. The TUG robot alone is in over 100 hospitals in the United States [12].

Even though so many hospitals employ these TUG robots, how much time can they really save? Aethon, the manufacturer and distributor of TUG robots, performed a few case studies in order to understand exactly how efficient a TUG robot is.

In one case study at UPMC St. Margaret hospital in Pittsburgh, PA, Aethon tested to see how much time TUG robots would essentially save the hospital. St. Margaret was having problems with hand-to-hand deliveries. An employee at the hospital was quoted as saying, "it was difficult to keep up, especially on evenings and night shifts, when staffing is at a minimum. There were complaints from Nursing about slow deliveries. My staff was discouraged." After the TUG robots were implemented, they became relied very heavily on. For instance, they made 86 deliveries in one day. By using three TUG robots, the hospital saved an average of 62.3 hours of work per week, which is equal to about 1.5 FTE (Full Time Employees) [13]. The results of this case study are undeniable: the TUG robot is extremely time efficient.

The previous case study is clear evidence that the TUG robots improved delivery times and ultimately wait times, but how reliable are these robots? Another case study in Maryland took polls before and after TUG robots were employed by the hospital. One area that the poll took into consideration was, "pharmacy delivers medications reliably". Once the results were in, it was determined that the reliability was increased by 23% [13]. Incredibly, the TUG robots can cut so much time and also remain very accurate. And even though the TUG robot is one specific type of robot, courier robots everywhere are helping hospitals to cut wait times [13].



Figure 2: Robot specializes in ICU room

Hospitals are currently overcrowded and unless something changes, it looks like it's only going to get worse. But this is unacceptable. A patient in a crowded hospital has a 5.6% higher risk of dying than someone in a non-crowded hospital [14]. Knowing that fact how is it possible that hospitals can ever allow themselves to get overcrowded? Once again, employing courier robots is the solution to this problem.

By getting patients out of hospitals more quickly, the overall wait time is reduced. Ultimately, this means that by having enough staffing to effectively take care of patients and heal them, the wait times will be reduced. Instead of hiring nurses to run back and forth all day, courier robots can do it more quickly which allows nurses to spend more time with patients.

There is a direct correlation between how much time a patient spends with a nurse and how quickly they are released. And although the courier robot isn't the one spending time with the patients, the courier robots are the ones that allow the nurses to spend time with patients because they save so much time. Four courier robots can effectively do the same thing as two nurses could do in any given day. This means that instead of wasting two nurses' talents on walking around to make deliveries, they can spend more time with the patients, which is extremely important [13].

A study found that if a hospital would increase its nursing rate by just 25%, the 30-day mortality rate would ultimately decrease by 20% [15]. Thanks to the incredible amount of time courier robots save, hospitals and nurses would be able to make this increase without actually having to hire any extra nurses, but by employing just a few courier robots.

Back in 2005, courier robots were capable of making just over 35 trips a day [16]. Compare that with today, just a few years later, where courier robots can make over 80. That is more than double what was possible before. With continued improvements to courier robots, they will soon be capable of saving incredible amounts of time for hospitals and will be a viable solution to overcrowding.

The time efficiency is a great aspect of the courier robots, however, another feature that must be noted is its ability to save hospitals money. Its economic efficiency is only matched by its ability to save time.

With all the benefits of saving time that courier robots include, it would seem like their costs must be high. However, this is not true. One of the biggest upsides of the courier robot is that it can actually save hospitals money while increasing efficiency and even reliability.

A study at the Virginia Health Science Center found some interesting results after employing courier robots. Where five human couriers originally made deliveries, the hospital decided to use six courier robots. To initially install all of the robots, it cost the hospital \$612,500 and included an annual cost of \$154,500. However, the total amount of cost the hospital was allowed to dispose of each year was about \$448,000 after employing courier robots. The robots paid for themselves in just five years. [17].

Although these statistics sound like great news for hospitals, note that the previous study was done back in 2000. The courier robots have just got more and more economically efficient till this day.

The previously mentioned company Aethon also researched effects courier robots have on the economic efficiency of the hospitals. They researched the Return on Investment, or ROI, of the TUG robots. They discovered that if a hospital employed just one TUG robot that worked two shifts a day for seven days a week, it would save the hospital a total of 2.8 FTE (Full Time Employees). While this may not seem like an overwhelming amount, note that the price of one TUG robot to install is less than one FTE. This is a total of 185% return on investment [18].

Although the initial installment of a courier robot is fairly cheap, the question of annual upkeep must be raised. Because the courier robots are so well designed, after they are installed they barely cost the hospital any

money at all. A single Help Mate robot costs a hospital about \$26,000 a year through operating and repair costs [17].

For an example of how much a hospital could save by employing courier robots in their hospitals, take for example the Samuel Simmons Memorial Hospital in Barrow, Alaska. There are a total of 18 nurses who work this hospital [19]. And the average salary for a nurse is quoted at \$61,300 [20]. However, nurses also make a lot more through benefits. These benefits can add up to around \$15,000 [21]. By employing just six courier robots, at an installation cost of \$612,500, the hospital could save a lot of money.

Six courier robots could do the job of almost 12 human couriers. Now this doesn't necessarily mean that they could replace 12 whole nurses, but the hospital would be able to release about five of them [20]. This translates to an average savings of \$381,500 per year for the Simmons Memorial Hospital. So after roughly two and a half years, the Simmons Memorial Hospital would be able to see savings.

In a separate study professionally done in another hospital, it was determined that if the courier robots were all installed in a hospital and paid for at once, it would take only two years and five months to see results. However, if they were gradually installed and paid for over time, it would take about an extra year to see savings [17].

Humans have certain flaws when it comes to working that employers simply can't get around. For example, it is human nature to need breaks from work (AKA vacations). Also, humans can't help but get sick. The average nurse gets two weeks off for vacation as well as one 'sick' week [21].

This is an aspect of courier robots that is extremely important. They do not need vacations, they do not require time off, and they do not get sick (besides the rare and occasional repairs). So as well as all the benefits already discussed, the unrequired time off deserves to be mentioned.

How important is it that hospitals actually save money? With all of the patients that visit every day, it's hard to imagine that they could possibly be losing money or that they could be struggling. Over a million people worldwide are admitted into hospitals everyday. However, hospitals are having a hard time staying afloat in today's economy.

In the third quarter of 2011, more than 75% of hospitals in Nevada lost money. Although the national average is lower (only about 33% in 2010 were operating at a loss), it still proves that hospitals need to conserve money wherever they can. Losing money is the cause of an even larger problem: closing Emergency Room doors. The closed ER is directly correlated to the loss of money. The New York Times suggests that in the past 20 years, America has lost over 20% of its Emergency Rooms. These ER rates are dropping at an alarmingly fast rate.

This is a major reason that hospitals need to include courier robots into their infrastructure. Although they provide a priceless benefit of saving time to hospitals, their biggest advantage is the money they are able to save the hospital.

While over 100 hospitals currently employ the TUG robot, it is only a small percent of total hospitals. There are a total of 5,754 hospitals in the United States. This means that only about 1.7% of hospitals nationwide use this type of courier robots. With all the benefits, why don't more employ them?



Figure 3: Robotic Surgery at the Montreal General Hospital

The biggest reason why more hospitals don't have courier robots is the initial costs. With hospitals hemorrhaging money and struggling to keep Emergency Room doors open, spending almost half a million to

install a realistic amount of courier robots to be effective seems out of the question. However, these same robots would start to save the hospital money in just a few years.

Hospitals today are just not efficient enough. The employees work hard, but with the levels of understaffing and incredible amount of patients walking through the door, it is hard for them to keep up. Courier robots are the solution. These innovative and autonomous machines can drastically cut wait time and increase the amount of time patients are able to spend in person with the nurses. And with all the advantages they bring when it comes to time efficiency, it would seem like they must be pricey. However, they are not. In just under two and a half years, courier robots would start to see a Return on Investment (ROI). For these reasons, courier robots provide a blueprint for increasing efficiency in medical care facilities and are a viable option for hospitals worldwide patients of those hospitals. They will be saving money and giving the hospitals more time to work directly with the patients. However, would it be wrong if some of the nurses were laid off to instead employ courier robots? If it costs money to employ these robots into hospitals then they have to eliminate other costs that they are spending. Nurses might be one of those costs. According to reports by El Camino Hospital, it has been said that they would cut costs by firing up to 140 workers. They did not specify if it was due to the fact that they were investing in 19 TUG robots. Alicia Caramenico at Fierce Healthcare said, "We've seen Aethon's TUG robots in action before, and they aren't meant to replace nurses or other medical staff." She also said the courier robots are marketed to augment human workers, which is giving the medical personnel more time to work with the patients and less time hauling supplies. If the company would bring in 19 courier robots, it should mean that a maximum of 38 nurses' jobs would be replaced, but saying that 140 workers would be laid off doesn't show that the job cuts are because of the installation of the robots.

The NSPE code of Ethics for Engineer's fifth fundamental cannon states that "Engineers shall act for each employer or client as faithful agents or trustees". Could the implementation of the courier robots not be considered faithful to the workers of hospitals if they are causing job cuts to those workers? Many people might argue that it is unethical, but no harm is being done by implanting these robots into hospitals. Many studies have shown that the medicine field is one of the most quickly expanding industries and many more jobs will be opening up for nurses who have been laid off. The total level of humans needed in hospitals may continue to rise giving new jobs to workers everyday [22].

Another ethical concern of courier robots being implemented into hospitals is the simple fact that they are robots. Is it morally wrong for robots be performing a job that humans could do themselves? What if a situation occurred where a young child was in the hospital about to receive surgery and a strange machine rolled up to him/her carrying the supplies needed for the operation. The child might feel uncomfortable or possibly even frightened by the courier robot. People may argue that it is wrong for this situation to occur of making the patient uncomfortable. The NSPE Code of Ethics for Engineers states that they hold paramount for the safety of the public. If the patients are being frightened by the robot then this would cause them to feel unsafe and would violate the code of ethics. This is not a crucial violation in this type of situation because not only are the workers in complete control of the robots and know that they cause no harm, but these uses of robots in hospitals are actually saving more lives by the extra amount of patient care they are allowing the nurses to put forth. While ethics are a vital importance that all engineers must consider, the use of courier robots in hospitals fits within the code and should remain an ethical technology used in hospitals across the country.

3. CONCLUSION

In today's world, many patients may be in urgent need of care, but the nurses' attention may be focused on more mundane tasks such as filling prescriptions or tracking down medical records. However, an innovative technology designed to assist the nurses in such tasks are courier robot, which are highly functioning machines that can successfully navigate a hospital and deliver medical supplies and other necessities to the nurses and patients. This paper will focus on the enhanced efficiency and cost effectiveness that occurs in hospitals that have installed courier robots (more specifically, the TUG robots). These autonomous robots bring countless benefits to medical facilities, nurses, and patients by saving time and they are helping to increase proficiency in hospitals.

This paper will incorporate the use of statistics and examples to demonstrate that courier robots operate in a manner that is both cost-effective and error-free. This paper will conclude by explaining how the courier robots, including the TUG robot, are great blueprints for future health care technologies.

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