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Machine Learning based Robotic End Effector System for Monitoring and Control of External Bleeding of Vehicle Accident Victims, Review Paper

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Abstract

Vehicle accidents are on the rise in the roads due to over speeding, poor roads, and misjudgment during driving, not forgetting overloading and lack of proper vehicle maintenance. Private transport has increased rapidly, thereby resulting in many accidents on the roads. Whenever there is an accident, it has been realized that some accident victims who would have survived the accident end up dead due to continuous bleeding. As a result, many lives are lost because of a lack of emergency measures to avoid that constant loss of blood through external bleeding. In this regard, there is a need to design a robotic system based on machine learning (ML) to monitor and control the external bleeding from vehicle accident victims in the shortest possible time through the utilization of software such as SolidWorks, Matlab, and proteus. The nanotechnology-based system interfaced with the robotic end-effector shall be used to apply to stop gel through the utilization of Comsol software. The robotic system shall be integrated with a monitoring system for precise and useful quantification of the bleeding wound, thus the importance of machine learning to achieve accurate information.

Keywords

Machine Learning, monitoring of external bleeding, nanotechnology, Robotic end effector.

INTRODUCTION

The issue of sense is fundamental in robotics applications such as in the medical field, for instance, the sense of touch is critical for detection in the medical field to monitor desired objects of interest. This is needed for detecting smoothness and roughness as the response to the sense of touch ([26], 2013). MEMS-based bio-medical sensors are analyzed in detail since MEMS devices are becoming popular in detecting biomedical-related issues such as glucose bio-inspired robotic fingers have utilized the advantage of tissue softness characteristic in sensing surgical pressure variations ([18], 2012).

Some sensors have been analyzed for force sensing application in robotic hands, especially tactile sensors. MEMS and silicon have been used to improve the efficiency of these tactile sensors in robotic hand operations. For instance, piezoresistive and polymers have been used to enhance grasping concepts. In this regard, it is justified to pursue the design of an optimized robotic hand that can mimic the real human hand ([1], 2015). One of the features of cooperating like human beings is the grippers and manipulators which have been designed as autonomous making them operate or maneuver in difficult environments ([12], 2017).

According to Oddo et al piezoresistive sensor system has been explored at the microscale to improve the whole system of sensing effectively ([12], 2017). Information taken using tactile sensors can be processed using machine learning in order to guide the robotic system to perform even in an unknown environment ([21], 2008).The skin provides a large variable degree of sensitivity since it is the largest organ in human beings.

Blood leakage and blood loss are a serious and real threat to human lives and up to date, more than 40% of adult blood volume can be lost thus high mortality ([31], 2018). Road traffic accidents (RTA) is among the top causes of high road fatality rate worldwide. Statistics from WHO, has confirmed that 5.6 million people die in unintentional injuries of whom 65% are victims of RTA yet, despite implementing many ways and efforts in trying to curb road traffic accidents, through use of machine vision systems and use of stiff penalties and fines, the annual number of deaths is still on the rise. Therefore there is a need for serious investigations in the epidemiology of RTA ([13], 2014).

In the whole world, road traffic accidents have claimed many lives at an alarming rate and an estimated 3 million injuries every year. Although advancement in technology had resulted in minimum reduction due to autonomous driving, human driving is still increasing, posing more serious accidents thus, a lot has to be done in the automotive industry

to minimize loss of life. In this regard, robotics can play a role where medical attention is of need for the injured person in the vehicles ([20], 2019). Since vehicle safety is one of the major priorities for any human when he/she is in a vehicle or any mode of transport. In this regard, many types of research have resulted in developments of safety features for the vehicles such as airbags for the rear front and side-ways, not forgetting seat belts. With all these efforts, vehicle accidents are resulting in many victims who instantly die on the spot whilst some injured end up losing their life due to lack of instant medical attention within the vehicle as some preventable deaths are still left being unattended which is a cause of concern ([20], 2019).

The The fact that most accidents happen at night or in an isolated place along the road had caused more injured victims to eventually die because of a lack of immediate help in terms of the red cross, ambulance team, and police to the site. Due to this scenario relatives cry because of some injured who end up dying because of a lack of support. With all this in mind, a robotic system for real-time monitoring of the victims with first aid assistance has therefore been identified as the way to go. This had to be installed inside the vehicle in a strategic position which makes it robust even after the accident as it remains undamaged due to collision ([20], 2019).

Surgery systems based on robotics technology have been on the rise where MEMS and nanotechnology have been on demand to make designs within a microchip which are multifunctional, intelligent and robust. These microchips can be placed even inside the body, on tissue and even in the blood for different medical applications that need automatic real-time monitoring and control ([11]). These devices are being used to monitor and control different diseases within human beings ([8], 2015). A A prototype for a skin surface coupled with personal wearable health monitoring which can cater to various body surfaces and positions within the body has been developed for instance scenarios where sensors are placed on the arm wrist to sense blood pressure based on waveforms ([15], 2018). Approximately 1.3 million people die annually as a result of road traffic accidents and more than 91% of road traffic accidents are from low and middle-income countries such as Nepal ([7], 2020).

Optical non-intrusive based methods have been used in detecting blood through the utilization of infrared ray or visible ray from a semiconductor laser ([30], 1994). A human being has got many senses however the sense of touch has dominated so much especially when it comes to environment perception for instance through the utilization of surface texture for detecting objects ([26], 2013). The issue of blood loss is a serious issue because a certain amount of blood is not replaced, this results in death as this had been witnessed at accident victims and on the battlefield. Many methods have been used in trying to minimize or reduce this blood loss through the use of pressure dressings and absorbent materials. A quick Clot can instantly and successfully stop bleeding by absorbing large quantities of fluid and concentrating on platelets to augment clotting however, this is has been implanted only to compressible and exposed wounds ([4], 2009).

In this era for innovation and industrialization for the betterment of our society and economy, transport, and safety cannot be separated. Therefore, fatal injuries on the road need a research approach to stop. Robotic manipulators rely on image systems for proper guidance to surpass human limitations by introducing automated targeting and treatment delivery methods for surgeons ([14], 2015).

Robotics in medical field

End effector position calculations only based on kinematic proved to be less effective especially in the joints and links of the robot as a result, designs based on machine vision can be implemented in the surgical tools so that operations can be improved. Tool operations algorithms were developed for guided tracking ([9], 2018). Robotics end effectors application in the medical field has become very popular, needles are being used in surgery with the help of machine vision techniques ([29], 2008).

A Although robotic systems are now being applied in the medical field, it is still entering at a slow rate especially in complex medical situations, however, outside the operating room robots can still assist human beings like in blood sampling, force sensing and even guiding robots position and its orientation like guiding the needle tip ([32], 2018). Diagnostic blood testing which is very vital in the medical field is being enhanced through an image-guided venipuncture robotic system thus precision, time, and efficiency are guaranteed ([2], 2017). Micro-actuator technologies based on nanotechnology concepts such as the Shape Memory Alloy (SMA) have led to innovations such as the miniature ultrasound motors which can be implemented in dexterous artificial hands and these latest technologies boosted the number of degrees of freedom for robotic joints thus much better flexibility and efficiency ([22], 2002).

Many technologies have been introduced to reduce or eliminate accidents on the road such as automatic speed control based on ultrasonic sensors, automated collision avoidance systems, tire pressure monitoring systems for preventing accidents but all this had been of benefit to a lesser extent because accidents occur due to many reasons. One of the significant reasons is human error which has caused many casualties. Systems have been designed again through research to come up with airbags so that the harm to the accident victims can be reduced however this is not 100% because accidents differ in their intensity and type of collision thus in vehicle collisions some scenarios are helpless however in some cases quick assistance like red cross can be of great help if it happens to be available in time. In this regard, it has been realized that some victims die due to lack of instant support, for instance, external bleeding can lead to death, and if quick assistance is rendered many lives can be spared from death. Since accidents occur at any place and any time, immediate help cannot be found to provide service which can stop external bleeding as the victims wait for an ambulance or Red Cross. In this case, there is a need to

design a robotic end effector which can instantly monitor external bleeding and automatically stops the bleeding thus saving lives.

Using the bio-inspired system, healing of the wound goes through different stages using chemicals that are released to initiate the healing process at the site of the wound, and the process involves inflammation, wound closure, and matrix remodeling ([27], 2008). The The advancement in robotic application in the medical field has resulted in soft robots in the medical field, and it has resulted in the efficiency and precision in complex tasks ([5])([3], 2018).

Robotics technology has got many applications in areas or situations where there is narrow space and where visibility and point of need are not clear for instance, in the medical field where the sensors need to mimic the soft skin and real hand dexterity to achieve this, the need to design and develop robotic manipulators and end effectors which can give maximum performance in a limited space with high sensitivity such as the human tissue ([10], 2019). Robots needs to have a closed-loop system so tasks which are thought being only accomplished by humans can also be done through the Implementation of the complex sensory system though thus this is an area where there is more research needed to have robots which similar human character ([6], 2018).

Robots have gained much favour in medical applications, and recently soft robotics that mimics human characteristics are now at the centre stage of research ([23], 2013). A non-contact handheld sensor based on near-infrared had been used for wound imaging, and this system had managed to differentiate between a wound and a healed one ([16], 2016). Optical imaging can be limited to wound depth of microns to mm but NIRS go deeper to around mm to cm([16], 2016).

Machine vision systems

Machine learning is of significant contribution in imaging to have perfect results therefore, artificial intelligence has to be explored in detail. MEMS field contributed to the development of challenging cantilever designs which have gained favor in the detection of disease([17], 2015). MATLAB has been implemented in the analysis of wound images and classification through consideration of healing status including color changes in the process. A collection of wound image databases from the open-source wound images can be collected before segmentation techniques are implemented to extract the region of interest ready for filtering to remove noise from wound images, reduction in the area of the wound indicates healing. Segmentation of the wound from the wound image involves projecting the needed information by identifying the region of interest ([19], 2014).

The release of proinflammatory mediators leads to the rapid expression of adhesion proteins on the surface of endothelial cells of the vessel wall and other chemoattractants that begin to recruit and guide leukocytes to the region of the injury. Neutrophils arrive at the wound site soon after the injury to deal with invading pathogens ([28], 2019).

MATLAB has great power and merit when it comes to matrix operating however, when implemented in real-time functions such as camera in real-time processing , digital image stitching and feature detecting it is too slow([25], 2017). There is a need for another efficient tool designed for computational efficiency and with great focus on real-time applications as a result, a new C ++ skin image processing program based on OpenCV has been developed which when compared with MATLAB, OpenCV is a free open source image processing library and very efficient for processing real-time video images. Above all, the OpenCV library is a very useful tool in image processing due to the distinct interface to another compiled language. The ongoing video program is successful for recognizing edges, removing skin surfaces, ROI computations, just as face location ([25], 2017).

MATERIALS AND METHODS

Table 1: Summary of related works

Title	Author	Methods and brief description	weaknesses	strengths	uniqueness
Robotic Arm and Image Processing	Koparde et al., 2020	The detection and recognition are done using OpenCV library of Image Processing in python. While all the processing is done on raspberry pi which works on Raspbian OS based on Debian-Linux OS.	The system cannot be in position to deal with complex images such as bleeding wounds.	Raspberry Pi offer flexible control for the robotic arm. The total programming model is developed in Python which is very compatible with controller being used for the robotic arm control.	The robotic arm is based on 4 Degree of Freedom (4 DOF) . is quite good for achieving the task without complications.
ROBOTIC ARM WITH	Therese, 2018	Raspbian OS based on Linux is used in	The system relies on color for	A robot is capable of detecting and	A Robotic Arm with Real-Time Image

REAL-TIME IMAGE PROCESSING USING RASPBERRY PI , BOTH AUTOMATED AND MANUALLY		raspberry pi for processing the hardware. Code is written in python for identification and detection of the object and its color. Simple CV libraries have allowed enhancing image processing for color of object and for controlling robotic arm for pick and place.	identification which is a challenge when background is not considered and also light needs to be taken into consideration for precision and accuracy results.	placing the pre-specified object. The code for detection of color has been written in Python which is very compatible easy to link with robotic arm control.	Processing using Raspberry Pi has been designed for fast identification and detection.
A review of semantic segmentation using deep neural networks	(Guo et al., 2018	Use of semantic segmentation which has the ability to segment an unknown image into different parts and objects.	It often occurs that the best methods for a dataset are fine-tuned for only the imagery of a specific situation, place, or context, so the generality is unclear which a challenge is. 2. Determine the amount of data necessary to train the algorithm is a challenge as some require enormous amounts of labeled datasets	1. It can improve computational efficiency. 2. It can improve accuracy by eliminating background noise. 3. It can give both theoretical and deep insights into both how visual systems work and what the limitations are. 4. Having extremely accurate image segmentation would be very beneficial.	Some of the top methods require rather heavy usage of near-supercomputers for the training phase which may not be available in all contexts. The system is now intelligent and better trained to handle new images.
Deep Learning Techniques for Medical Image Segmentation	Hesamian et al., 2019	medical image segmentation and batch normalization	They require a large number of annotated samples to perform the training task. Collecting such huge dataset of annotated cases in medical image processing is often a very tough task and performing the annotation on new images will also be very tedious and expensive.	Deep learning techniques have greatly improved segmentation accuracy thanks to their capability to handle complex conditions.	This survey is focusing more on deep learning techniques applied in the medical segmentation, has a more in- depth look into their structures and methods.
Deep Reinforcement Learning for the Control of Robotic Manipulation : A Focussed Mini-Review	Liu et al., 2021	Deep Reinforcement Learning in Robotic Manipulation Control	The challenges of learning robust and versatile manipulation skills for robots with DRL are still far from being resolved satisfactorily for	learning algorithms are safe, reliable and predictable in real scenarios, especially if a move to other applications that	Deep Reinforcement Learning algorithms for the Control of Robotic Manipulation for guiding the movements of robotic joints.

			real-world applications. DRL-based methods are not widely used in real-world robotic manipulation applications due to sampling efficiency and generation, Where more progress is still required.	require safe and correct behaviors with high confidence, such as surgery or household robots taking care of the elder or the disabled.	
Computer Vision Based Robotic Arm Controlled Using Interactive GUI	Intisar et al., 2021	This paper presents a design and implementation of a robotic vision system operated using an interactive Graphical User Interface (GUI) application.	The device also has a few limitations: (i) the robotic arm goes through the required motions even if the object picked up is dropped, and (ii) there is no feedback mechanism for the system apart from being watched over and reported by the user.	The main advantage of the design compared to previous attempts is user-friendly operation and flexibility.	The microcontroller used to control the system can be changed to a Raspberry Pi, allowing all joints of the robotic arm to be manipulated simultaneously. A line of motion camera can be added to the system instead of a webcam, which would allow the workspace to be three-dimensional to two-dimensional.
Research on Face Recognition Based on CNN	Wang & Li, 2018	CNN and python library. Convolutional and down sampled layers of CNN are constructed using the OpenCV convolution function and the down sampling function.	CNN issue of large datasets is the challenge unless if pre-trained is utilized	This article simplifies the CNN model by layering the convolutional and sampling layers together.	The basic principle of multi-layer perceptron MLP is studied to grasp the full connection layer and classification layer in face recognition.
Brain Tumour Segmentation Using Convolutional Neural Network with Tensor Flow	(Malathi & Sinthia, 2019	convolutional neural network for MRI brain tumor segmentation using tensor. segmentation is performed using various tools like MATLAB, LABVIEW, and many others. Python programming has been used .	The proposed work utilizes python programming instead of MAT LAB. Because the features are listed below in order to choose 1. Python code is more compact and readable than MATLAB 2. The python data structure is superior to MATLAB 3. It is an open source and also provides more graphic packages and data sets.	The accurate segmentation helps in clinical diagnostic, it also helps to increase the lifetime of the patient. It helps to perform the segmentation accurately.	Segmentation of brain tumour implemented using CNN architecture based on Python code.

Wound image segmentation using clustering based algorithms	Farmaha & Banaś, 2019)	Usage of neural networks or DNN usage of GPU-parallelized computations to increase speed performance,	High dependence on training data. The heterogeneity of training images affects the allocation of features and segmentation. For better results, more homogeneous images are needed, fixed size and shape segments are needed for autoencoder.	Provides improvement of the results during data accumulation. Autoencoder, as one of the simplest, plays an important role in solving clustering problem and is present as an important part of many methods.	Based on the results it can be stated that neural networks can be used while solving image segmentation problem.
Classification of Ulcer Images Using Convolutional Neural Networks	(Nilsson & Velic, 2018)	The need of rewriting the functions for augmentation, provided in Keras is a challenge.	One issue regarding the implementation of the network includes the drawbacks of Keras. The library has many useful tools and is simple to use, but the structure for building networks does not allow editing of individual building blocks in many cases. The limited data set was the major concern during the study as it affected the results as larger data sets are typically applied for training CNNs.	Increasing the data set could yield better performance for classifying venous leg ulcers. A larger data set also introduces the possibility of including more classes, enabling the classification of other wounds as well.	For future data collection, variations in the images should be taken into consideration such as different lighting, angles, and taking the images from different distances. This would enable the network to recognize the ulcers in a larger variety of settings which could potentially make the network's predictions on images taken from a closer distance are more certain.
Skin Cancer Detection : A Review Using Deep Learning Techniques	Dildar et al., 2021)	This review is focused on ANNs, CNNs, KNNs, and RBFNs for classification of lesion images.	One of the major challenges in neural network-based skin cancer detection techniques is the extensive training that is required, which is a time-consuming process and demands extremely powerful hardware.	CNN gives better results than other types of neural networks when classifying image data because it is more closely related to computer vision than others.	Autonomous full-body photography will automate and speed up the image acquisition phase. For accurate skin cancer detection in dark-skinned people, a neural network must learn to account for skin color and size variations using enough images.
Applied sciences A Systematic Overview of Recent	(Marijanovi, 2020	Create precise 3D models of the segmented wound surface. The system would	There is need of high pixel smartphone and RGB-D cameras with high computation power.	Wound assessment being fast and accurate in order to reduce the possible complications, and	Due to the improvements in automated wound analysis, the advent of

Methods for Non-Contact Chronic Wound Analysis		be able to autonomously detect wounds, record them from multiple views and create precise 3D models of the segmented wound surface.	Contact methods have drawbacks that are easily overcome by non-contact methods like image analysis,	therefore shorten the wound healing process.	artificial intelligence and the robotic systems can be foreseen. The future development will see the realization of an AI-driven automatic system for wound analysis comprised of robot manipulator with an attached high precision industrial 3D camera and high resolution RGB camera.
Convolutional neural networks for wound detection: the role of artificial intelligence in wound care	Ohura et al., 2019	This study explored whether or not wound segmentation of a diabetic foot ulcer (DFU) and a venous leg ulcer (VLU) by a convolutional neural network (CNN) Methods: CNNs with different algorithms and architectures were prepared. The four architectures were SegNet, LinkNet, U-Net and U-Net with the VGG16 Encoder Pre-Trained on ImageNet (Unet_ VGG16).	CNNs for wound detection showed good segmentation accuracy when using the U-Net_VGG16 architecture. However, in terms of the calculation processing, U-Net was considered to be the most practical.	Best results were obtained with U-Net as it demonstrated the second-highest accuracy in terms of the area under the curve (0.997) and a high specificity (0.943) and sensitivity (0.993), with the highest values obtained with Unet_VGG16.	The U-Net CNN constructed using appropriately supervised data was capable of segmentation with high accuracy. U-Net was also considered to be the most practical architecture and superior to the others in that the segmentation speed was faster than that of Unet_VGG16.
Deep Learning on Wound Segmentation and Classification : A Short Review and Evaluation of Methods Used	Kaswan et al., 2020	Methods used include Convolutional neural networks (CNN), Fully convolutional networks (FCN) and Recurrent neural networks (RNN) and several other architectures have been proposed with AlexNet being the most well-known architecture for classification purposes	Many of the approaches from the literature, requires a huge chunk of labeled wound datasets and some find it difficult or impossible to create such sets. Deep learning also requires a high amount of computational resources to achieve the best accuracy.	The method can be implemented on a mobile platform to assist the patient in their own wound care and surgical recovery from the comfort of their home. Deep learning can be produce results with great accuracy and repeatability.	Recent work suggests that most of the wound segmentation was done on deep learning techniques which have been a good sign. The CNN-Based Segmentation was found to produce compelling evidence that the strategy proposed is more reliable when compared to other research reported, with regards to their method approaches on wound segmentation.

DISCUSSIONS

The study in different reviews had indicated the issue of image identification and classification using different platforms. Image processing has been done using ordinary image processing which proved to work with general images however when it comes to medical images such as ulcer wounds studies have shown that better systems need to be used.in this case, machine learning was introduced to enhance the issue of image analysis and classification. Shortfalls insensitivity, process time, accuracy, and efficiency were still major issues as result this paved way for deep learning where using convolutional neural network (CNN) has been implemented but this did not produce perfect results. This pushed for different architectures such as U-Net, AlexNet, and VGG16 among others have been analyzed to verify the one with better efficiency.

However, medical images are 3 dimensional (3D) and this means architectures for images analysis are still to be verified which can cater for 3D images. Issue of large data sets have been a challenge in spite of that, CNN's ability for pre-training has put it upfront to analysis further for implementation in image processing. For the code for image processing and analysis, from the review, it has shown that python OpenCV is much better than MATLAB. Moreover, a robotic arm with few joints reduces the complexity of the design hence boost power-saving and speed of operation. From many authors' points of view, it is clear that complicated medical images such as bleeding wounds have not been looked at. The issue of implementing deep learning in python needs to be verified since authors have indicated that python in OpenCV is better than MATLAB. The reviewed papers were silent on the issue of control of the monitored conditions of wounds, therefore, there is more study needed to develop a system that shall rely on feedback from monitored bleeding wounds based on deep learning.

CONCLUSION

To conclude the image analysis studies in different reviews have shown great improvements especially in the medical field however, it has shown that there is still a lot to be done to verify amongst the architecture for deep learning, to analyze the issue of datasets and pre-training whilst utilizing python OpenCV. Also to analyze the 3D aspect of the image so that bleeding wounds can be interpreted well in order to get the area and the centroid values so that signals can be generated to guide the robotic arm.

RECOMMENDATIONS

There is still further study needed to develop a control system based on a robotic arm and image analysis system. There is still further study needed to control dispensing of fluid for stopping bleeding through the design of a system based on image analysis feedback whilst guided by the robotic arm. Future study on the robotic arm design which has minimum degrees of freedom (DOF) is much better as this reduces the complexity and response time of the system.

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