Descriptive Model for Phase Prediction & ML for Laparoscopic Surgery

Priyanka Tayde, Durgesh Mishra

Abstract*: *In area of non-invasive diagnosis of endometriosis is now accurately obtained by laparoscopic surgery. It involves the excision of the endometriosis, scar tissue and developed adhesions. In this surgery doctor visualize abdominal-pelvic region via laparoscope, telescopic lens, light sources and video camera.In our paper we demonstrate a system that uses descriptive model for phases that are generated from segmented form of video through extended use of corsets with effective non-monotonic phase sequences, which is an interactive model for visual summary of laparoscopic and robot-assisted surgeries. Such model may reduce learning curves in the OR for junior surgeons with limited access to complex laparoscopic procedures as a primary operator. In this procedure we are using a combination of SVM (Support Vector Machine) and HMM (Hidden Markov Model).We generated a formal descriptive model of surgical phases which is required for laparoscopic surgery for better understanding of surgical training and to improve patient outcomes. We used descriptive model of machine learning for high accuracy in Phase predictions and bag-of-words (BOW) model for final frame representation. We evaluated our system in various experiments in real time operating environment of surgery room as well as collected data sets.

Keywords: SVM; HMM; BOW, PRONET; Index Terms*: *About four key words or phrases in alphabetical order, separated by commas.

I. INTRODUCTION

It's an emerging paradigm from teaching & learning perspectives for medical science, Human anatomy and physiology student. Video based teaching and briefing is rich and powerful medium. It gives the visualization of step by step procedures. In the OPD at the time of the performing action what the next step will be taken is viewable to surgeons and student nearby. In this place timing will be matter & the next task will be performed as per that. The video stream will be analyzed thoroughly and after identifying different phases of operation a step-wise procedure will be generated and taught to students and robot assisted machine for surgery. In area of non-invasive diagnosis of endometriosis is now accurately obtained by laparoscopic surgery. It involves the excision of the endometriosis, scar tissue and developed adhesions. In this surgery doctor visualize abdominal-pelvic region via laparoscope, telescopic lens, light sources and Videocamera. In our paper we demonstrate a system that generates segmented form of video through extended use of corsets with effective non-monotonic phase sequences, which is an interactive model for visual summary of laparoscopic and robot-assisted surgeries. Surgical training out of the operating room (OR) using simulation has widely spread this last decade, especially in laparoscopic surgery. Training models may be inanimate such as video trainers (VT), virtual reality (VR) and augmented reality (AR) simulators. There are many simulations exists for laparoscopic skills such as basic drills, laparoscopic cholecystectomy and appendectomy. In this research the video will classified into different chunks which is not available easily anywhere and can't be possible to take such multiple snaps from camera and any other recording system, because of timings of capture at same point and prohibited issues of legacy infrastructure. Video dimensions and angles are very important to perform actions in human body during surgery inside the lab. At that time faculty or senior can't explain each & every steps on that actual timing. From a segment of video stream multiple frames will be generated from different angles and 3D view. This video stream is an expanded form of actual steps and easily viewable like what actually need to be perform. Initially it will involve manual analysis of video and that further will be analyzed by automated system and on the basis of that analysis next stream will be created, which is actually an elaborated video stream/ frame from large recorded video. This research for briefing the video stream is very helpful for space exploration, moon transition to get the different angle and view from CCTV footage and robotic system and apart from medical science studies also for various different leanings like kathak rehearsal (for mudras), step by step beautician techniques & many more other fields.

II. TECHNICAL APPROACH

Initially we have a video stream as data sets and will perform segmentation over it on per frame basis. For that purpose our system will use SVM and HMM which is an implementation of structural SVMs for sequence tagging, it includes an optional beam search for fast approximate training and prediction which is required for next procedure from the taken video frame. (HMMs)Hidden Markov model is helpful in our system for classifying discrete finger movements obtained from the Electrocardiograms of video streams doing a finger tapping experiment.

The classifier decisions are based on a subset of low-frequency time domain and high gamma oscillation features. On per segments, objects which are important are having in-class variability at the geometric level like the set of shapes which we can consider here and various different phases.

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From the large video stream final frame will be represented using the bag-of-words (BOW) model.

A. SVM Table

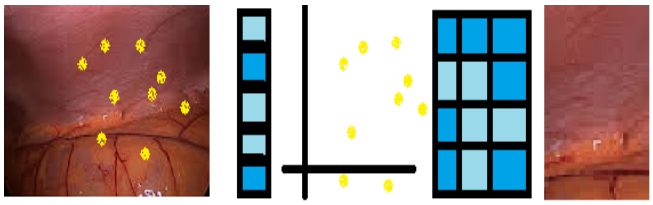
SVM Classification

pi = 1	1	2

B. OUTPUT

See the below figure in which we can see classification and obtained image frame, The above table demonstrate the experimented value of pi.

C. Figures



In SVM composed data is represented as n vectors xi, each value of xi will also be associated with a value yi. Our dataset D is the set of n couples of element (xi, yi), the definition of dataset as per the definition is:

$D = \{(xi, yi) \mid xi \in Rp, yi \in \{-1, 1\}\}\ Ni = 1$

Using the model firstly we will extract data which are type of training model used for simulation, i.e. VT, VR or AR simulators, animals (porcine or others), cadavers; type of advanced procedure evaluated, i.e. gastric, colorectal, or small bowel procedures, pancreatectomy, splenectomy, keratectomy, or adrenalectomy; type of study, i.e. RCT, non-randomized controlled trial, single-group pre-/post-test, case series assessing any outcome or being only descriptive; purpose(s) of the study, i.e. training or assessment, model description (i.e. description of either a procedure on a tool or a whole course), satisfaction of trainees, construct validity of a model, transfer of skills and learning curve. The qualities of different training models were assessed for each procedure. These qualities were fidelity, content, construct, predictive and concurrent validity, reliability, and training ability. Training ability referred to any kind of impact, whether it assessed progression on the simulation device itself (pre- and post-test), transfer of technical skills, or impact on practice. Through a descriptive model providing a basis for comparing and generalizing communication and coordination processes across different laparoscopic surgeries, we can distill guidelines for best practices, devise new training program curriculum and simulations to facilitate improved laparoscopic teamwork, and significantly impact surgical safety and patient well-being.

III. ANALYSIS

For data analysis purposes, we will combine the two video windows into a synced picture-in-picture format, which will allow us to simultaneously review the surgeons' actions both in and out of the body an integrated exploratory sequential data analysis technique that uses Pathfinder network scaling to highlight frequently occurring transitions among user, system, and environmental events. The descriptive models are different in nature from predictive models since they don't need to perform as accurately as the predictive models need to. Since predictions are for a potential future event and business wants to exploit that knowledge and take actions on the predictions, the reliability of the prediction matters a lot. A descriptive model, on the other hand, is describing the data in a form that allows for future action strategies, but it is not a precise event. Rather, it is a perspective into large quantities of data, so business can make sense of the data. It describes data in clusters or association rules so it doesn't need to be accurate, just approximate. Descriptive analytics has input variables, but their values and weights function differently. When a descriptive analytics model like clustering is complete or built, here is what we find:

- Number of clusters
- Cluster affinity (closeness of one cluster to another on the Euclidean plane)
- Cluster characteristics:
- Cluster name or ID
- Input variables and their values (or range of values) in each cluster
- Probabilities and correlations of variables within each cluster

That makes the model and its characteristics in descriptive analytics much simpler to review, understand, and use. In predictive analytics, a future event is predicted and that has to be exploited favorably. The focus is the event and, therefore, the usage is tied to the event as well. In contrast, the descriptive model output is an explanation of the data using a structured form like clustering or social network analysis. Once the output is analyzed the question of exploiting this insight becomes wide open to interpretation and innovation. Therefore, the descriptive model's output is not expected to meet any fixed criteria. We will elaborate it better in out next section. To make this video frames to be in different groups of chunks we use image clustering and classification. To compute data log in efficient manner we used k-segment image clustering corsets. Then further implemented by SVM which stands for support vector machine, this is useful to get pixel classification, texture feature, pixel feature, Homogeneity model and Gabor filters. The first image frame is obtained from SVM hyper plane that maximizes the minimum distance between any data points.

Now our major task in this research is to segment image in more accurate manner using descriptive model. Descriptive model is basically a mathematical process which is used to describe event of real world entity. As we are doing extraction of image from real time running video frame that image frame describe what happens in the past process of surgeries. So that this elaboration is useful for medical science students for demonstration, explanation,

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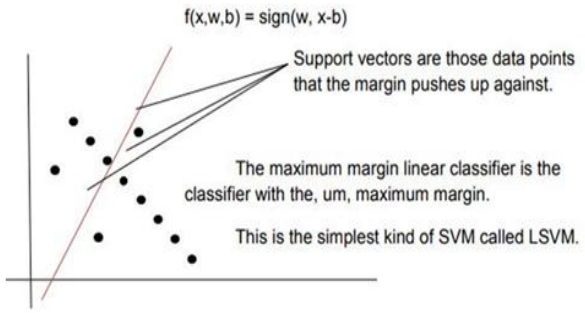
understanding and further explanation.

IV. DATA COLLECTION

Video recordings of the team's work will be collected during each of the surgeries. The video collected will include both the external video captured on a handheld video camera and the internal video captured by the laparoscopic recorder. The external video camera will be placed at the foot of the table directed towards the surgical working area encompassing both surgeons and laparoscopic video screens. In our institute there is a medical Centre where this surgery happens, so we have taken that recorded as well as live video to collect datasets and performed experiments on that.

V. SVM CLASSIFICATION

A. Figure



If an automated surgical video along with segmented video stream is available it is helpful for Robotic laparoscopic surgery as well as Non-robotic hand guided assistance systems as per the following key points:

- Visual magnification: use of a large viewing screen improves visibility.
- Stabilization: Electromechanical damping of vibrations, due to machinery or shaky human hands.
- Simulators: use of specialized virtual reality training tools to improve physicians.
- Proficiency in surgery.
- Reduced number of incisions
- This system is useful for automated machinery, medical learning students, and saves time and money & auto steps procedure for expert surgeons who
- Willing to make further surgeries based without much case studies.

SVM is a supervised machine learning algorithm which can be used for both classification and regression challenges. However, it is mostly used in classification problems. In this algorithm, we plot each data item as a point in n-dimensional space (where n is number of features you have) with the value of each feature being the value of a particular coordinate. Support Vectors are simply the co-ordinates of individual observation. Support Vector Machine is a frontier which best segregates the two classes (hyper-plane/ line). In SVM, it is easy to have a linear hyper-plane between these two classes. But, another burning question which arises is, should we need to add this feature manually to have a hyper-plane.

B. Description

The parameters of the maximum-margin hyper plane are derived by solving the optimization. There exist several specialized algorithms for quickly solving the quadratic programming (QP) problem that arises from SVMs, mostly relying on heuristics for breaking the problem down into smaller, more manageable chunks.Another approach is to use an interior-point method that uses Newton-like iterations to find a solution of the Karush–Kuhn–Tucker conditions of the primal and dual problems.[35] Instead of solving a sequence of broken-down problems, this approach directly solves the problem altogether. To avoid solving a linear system involving the large kernel matrix, a low-rank approximation to the matrix is often used in the kernel trick.

Another common method is Platt's sequential minimal optimization (SMO) algorithm, which breaks the problem down into 2-dimensional sub-problems that are solved analytically, eliminating the need for numerical optimization algorithm and matrix storage. This algorithm is conceptually simple, easy to implement, generally faster, and has better scaling properties for difficult SVM problems.

C. Future Scope

This will be very helpful automation system for Medical studying students, latest arising different surgical cases, and elaborated description of any incident happens captured by CCTV footage, modeling robotic behavior in a fixtureless assembly operation, remotely supervised robots used in space exploration and emergency response scenarios, etc. If an automated surgical video along with segmented video stream is available it is helpful for Robotic laparoscopic surgery as well as Non-robotic hand guided assistance systems. This is also useful for image processing and latest other surgery techniques. We can use phase prediction in space research also for demonstrating the visual of moon phases and other satellites.

D. Footnotes

To perform this experiment we have taken 5 videos of laparoscopic vertical sleeve gastrostomy (LSG) procedure performed by expert surgeons at the Aurobindo Hospital-Indore, MP. These video data sets are enough for testing the system with variability between data samples, while training the features and low-level classifier channels under the assumption of limited training data. To perform the surgical procedure the surgeons has to identify seven basic phases: (1) Port, (2) Biopsy, liver retraction, (3) Omentum removal, dissection, hiatus inspection, (4) Stapling, (5) Bagging, (6) Irrigation, (7) Final examination

E. Segmentation of video frames and phase predictions

The major task in our research is the extraction of images from the video frames and that image will further classified in more image frames in an efficient manner so as to predict further phases. As per the previous phase records we predict next phase descriptive model is helpful in determining what has been done.

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VI. CONCLUSION

In this work we demonstrated how the surgical process will be more representable. With the help of descriptive model and SVM image classification past phases are analyzed and on the basis of that new image frames are extracted from all view of angle. This procedure in incorporated in robotic machine which auto predict the next phases and surgeries becomes more result oriented. This research is useful for medical science student is getting the demonstration of all the procedure taken to perform particular surgery. The challenge we have faced in experimenting this research is to get accuracy in obtained image as well next predicted phases which tend to give accurate result if performed by robotic. In our next research we will try to overcome with this and proposed a new model for phase accuracy. As well as this research will be further expanded for image transition and image processing. Our future work will proposed a new model to predict auto procedure for laparoscopic and robotic-based surgeries including high accuracy in variation of phases.

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