

2016 ACS-IRG Pilot Grant



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PROJECT TITLE: REDUCING TUMOR RESECTION MARGINS VIA NATURAL MEDICAL IMAGE OVERLAYS THROUGH WIRELESS AUGMENTED REALITY HEADSETS

ABSTRACT:

BACKGROUND. WHILE AUGMENTED REALITY IN SURGERY AS A CONCEPT IS NOT NEW, THE LACK OF CAPABLE HARDWARE AND SOFTWARE HAD HINDERED ITS REALIZATION IN PRACTICE. WITH THE FIRST UNTETHERED AUGMENTED REALITY HEADSET BY MICROSOFT MADE COMMERCIALY AVAILABLE THIS WINTER OF 2016, HARDWARE HAS FINALLY REACHED THE CAPABILITIES TO PROVIDE COMPELLING, AND COMFORTABLE AUGMENTING SURGICAL VISUALIZATION. THIS HARDWARE NOT ONLY IMPROVES SPATIAL REASONING BETWEEN TOOLS AND TISSUES INSIDE THE BODY IN A NATURAL MANNER BUT ALSO PROVIDES AN INTERFACE FOR REGISTERING MEDICAL IMAGES TO VISUALIZE SUBSURFACE LESIONS IN REAL-TIME TO SHOW TUMOR BOUNDARIES. SOFTWARE FOR NEW, CAPABLE HARDWARE SYSTEMS IS NOW REQUIRED TO MEET THE DEMANDS OF COMPELLING VISUAL AUGMENTATION: HIGH FRAMERATE, FINE DETAIL VISUALS OF REGISTERED PREOPERATIVE MRI/CT SCANS, WITH CORRECT PERSPECTIVES AT ALL TIMES.

OBJECTIVE/HYPOTHESIS. OUR OBJECTIVE IS TO DEVELOP THE NECESSARY ALGORITHMS FOR REAL-TIME IMAGE REGISTRATIONS VIA AUGMENTED REALITY (AR) HEADSETS AND EVALUATE IMPROVEMENTS TO RESECTION MARGINS THAT WOULD SPARE HEALTHY ORGAN FUNCTION. WE HYPOTHESE THAT REAL-TIME IMAGE REGISTRATION THROUGH UNTETHERED AUGMENTED REALITY HEADSETS WILL IMPROVE VISUALIZATION OF SUBSURFACE TUMOR BOUNDARIES, IMPROVE REGULATION AND CONSISTENCY OF RESECTION MARGINS, AND CONSEQUENTLY SPARE HEALTHY TISSUE FUNCTION.

SPECIFIC AIMS. AIM 1 IS TO RELAY IMAGE REGISTRATION AND OVERLAYS OF LAPAROSCOPIC SCENES WIRELESSLY, AND IN REAL-TIME, TO HEAD-MOUNTED DISPLAYS. AIM 2 IS TO EVALUATE SURGICAL IMPROVEMENTS FROM IMAGE OVERLAY IN A USER STUDY ON A CLINICALLY-RELEVANT LAPAROSCOPIC SIMULATOR.

STUDY DESIGN. THE NOVEL CONTRIBUTION OF THIS PROPOSAL IS THE DEVELOPMENT OF THE (I) FIRST REAL-TIME ENDOSCOPIC VIDEO PROCESSING AND COORDINATED REGISTRATION OVER (II) WIRELESS COMMUNICATION TO AUGMENTED REALITY HEADSETS THAT PROVIDES (III) ACCURATE, STABLE, INTRACORPOREAL LINE-OF-SIGHT IN THE CORRECT PERSPECTIVE. A SYSTEM WITH THIS ALGORITHM RUNNING IN REAL-TIME WILL PROCESS STREAMING LAPAROSCOPE VIDEO AND DELIVER VIEWS TO AR HEADSETS, FOR THE FIRST TIME WITH CORRECT PERSPECTIVES. VOLUNTEERS FROM THE UCSD SCHOOL OF MEDICINE AND SCHOOL OF ENGINEERING WILL BE SELECTED TO PARTICIPATE IN SURGICAL RESECTION OF TUMOR PHANTOMS IN A LAPAROSCOPIC SIMULATOR. METRICS ON TASK PERFORMANCE AND COMFORT WILL BE GATHERED, AND HISTOLOGICAL SLIDES WILL QUANTIFY MARGIN IMPROVEMENTS.

CANCER RELEVANCE. TIGHT SURGICAL MARGINS DURING A TUMOR RESECTION CAN HAVE A CRITICAL IMPACT ON A PATIENT'S POST-OPERATIVE QUALITY OF LIFE. THIS CAN COME FROM PRESERVING NERVE FUNCTION (AS IS OFTEN A CHALLENGE IN PROSTATECTOMY), ORGAN FUNCTION (AS IN PARTIAL NEPHRECTOMY), AND NEUROLOGICAL FUNCTION (POSITIVE MARGINS HAVING UNEXPECTED DEGRADATIONS ON A PATIENT'S NEUROLOGICAL HEALTH). THUS, HEALTHY TISSUE PRESERVATION IS OFTEN OF THE HIGHEST IMPORTANCE TO THE PATIENT, WHERE EXCESSIVE REMOVAL CAN HAVE SIGNIFICANT AND UNPREDICTABLE DEFICITS ON THEIR POST-OPERATIVE LIFE. DESPITE PREOPERATIVE CT/MRI PROVIDING TUMOR BOUNDARIES IN SUB-MILLIMETER PRECISION, THESE 3D VOLUMES ARE PRESENTED AS 2D IMAGES ON FLAT-PANEL DISPLAYS WITH NO SPATIAL CORRELATION TO THE PATIENT ON THE OPERATING TABLE. THIS REQUIRES SIGNIFICANT COGNITIVE FOCUS FOR CLINICIANS TO MOVE BETWEEN THE 2D IMAGES AND THE LIVE OPERATING SCENARIO. OUR INABILITY TO DISPLAY *IMMERSIVE, REGISTERED* IMAGES ON THE PATIENT ANATOMY FORCES SURGEONS TO WIDEN SURGICAL MARGINS AND RESECT MILLIMETERS OF HEALTHY TISSUE, OR ELSE RISK CANCER RECURRENCE, REPEAT PROCEDURES, AND ADDITIONAL TRAUMA TO THE PATIENT.