Personal Statement

I think of myself as a constructive person. Assembling small components to achieve meaningful purpose has always been my excitement. Before entering the college, the excitement was converted into effective leadership as I planned multiple successful class activities such as designing a yearbook. In college, I joined a program, which aims to teach building mobile applications. As I implemented different components and combined them to make the whole application functional, I rediscovered my excitement during the developing process. So, I decided to experience the complete development cycle of a mobile app even though only the front-end half was taught. Taking online tutorials during my free time, I was able to implement various features of the application through trials and errors. When my own mobile app finally showed up in the App Store, the sense of achievement makes me determine to pursue my bachelor degree in computer science.

Assembling small parts to build towards a larger goal has always been my excitement. In high school, such excitement brought about effective leadership in many event planning, such as designing a yearbook. In the past few years, I was lucky to rediscover my excitement by implementing different components and combining them to make a whole application become functional. (写到这我还是觉得提高中不太好。) Although only the front-end half was taught in class, I was eager to experience the complete development cycle of a mobile app. I started to take online tutorials during my free time and I was finally able to implement various features of the applications after trials and errors. When I saw my own design finally showed up in the App store, I came out of this experience with the firm belief that computer science will be my life pursuit.

This experience also reveals enormous amounts of mechanisms behind one seemly-simple application to me. To fulfill my curiosity about underlying layers of modern applications, I took many challenging computer science courses such as Internet protocols, operating system, and distributed systems. I did well in these challenging courses. I believed these courses would lay a strong foundation for my computer science knowledge. I also applied my ability by joining a student start-up as an iOS application developer. Through collaboration, we built our own app, Vinci fitness. From this app, users can organize group fitness activities or join listing activities on the local map. We hoped to see that this application could improve social dynamics between people in fitness programs.

I explored further in the field of computer vision and graphics as I was hired by Professor Henry Fuchs to become one of the youngest research assistant in his group. Since then, I actively participated in computer science researches until the present time. Following experienced graduate students, I learned to build applications on state of the art augmented reality and virtual reality devices such as Microsoft Hololens and HTC Vive and basic knowledge about computer graphics and visions. As I gradually accumulated my knowledge base, I found myself capable of leading research project independently.

In the summer of sophomore year, working as a full-time research assistant, I was assigned to lead my first research project: assisting laparoscopic surgeries with augmented reality. The project’s goal is to explore the possibility of using augmented reality to help laparoscopic surgeons. Original laparoscopic surgeries require surgeons to conduct complex and detailed tasks such as cutting small tumor tissues and stitching based on 2-dimensional video output from a camera inserted into patients’ cavity. The largest challenge for the surgeons is the lost of hand-eye coordination: instruments’ movements in the video output are unintuitive because camera and surgeons’ eyes have different points of view. My research work expects to construct a pipeline which can reconstruct simulated patient’s cavity and place such 3-dimensional (3D) reconstruction inside head-mounted display (HMD) devices such as Hololens. Then we align the physical position of patient’s body relative to surgeons’ eyes. Thus, with this pipeline, surgeons who wear HMD devices can perform surgeries collaboratively as if they all can see through patient’s skin.

We took several steps to improve the pipeline. Components from varies hardware were utilized: I used depth camera with its programming interface and wrote shader program to display 3D reconstructed mesh on the Unity platform. I then calibrate the mesh to match the real objects by using visual markers to detect depth camera’s pose. We later discovered that the coordinate system of Hololens would sometimes drift away from its original position due to inaccurate spatial mapping. To compensate for the drifting issue, I used HTC Vive tracker tied with Hololens to provide constant position correction. I managed to complete this cross-platform pipeline within three months. My first leading research experience provided me with a wider horizon of research topics and trained my ability to discover the issue and methodology for solving problems.

The biggest bottleneck of this project as pointed out by professional surgeons is the poor quality of 3D reconstructed mesh. The laparoscopic surgeries, due to the small size of the surgical area and great danger of internal bleeding caused by inattention, require persistent high-quality visual output while none of the current commercial depth camera performs well in the simulated patient’s cavity. (这段和下面一段需要一个句子，比如 This biggest bottleneck did not discourage me but rather shape my honor thesis topic. )

To learn more about 3D reconstruction and find a way to refine the pipeline of my previous project, I decided to do my honor thesis on the topic of 3D reconstruction with Professor Jan-Michael Frahm as my thesis advisor and Professor Henry Fuchs as the first reader of my thesis after that summer. The goal of the thesis is to independently explore viable ways to achieve high-quality 3D reconstruction of the laparoscopic surgical area with customized algorithms and stereo camera setup. To have complete control of the reconstruction pipeline, I implemented all the algorithms myself starting from two common cameras placed in parallel. After a careful literature review of research papers on 3D reconstruction, I used basic block-matching algorithm as the depth reconstruction foundation of my pipeline. Then optimization algorithms are experimented and used to refine the reconstruction results. Local sub-block smoothing algorithm is used to smooth the boundaries between two parts of pixel points with different depth values on the surface; occlusion test is used to remove noisy pixels in the areas occluded to one of two cameras. After making a comparison between reconstruction results with and without refining algorithms, we concluded that the application of these refining algorithms would dramatically increase the quality of reconstruction. Then, another issue the thesis intends to solve is to reconstruct homogeneous surfaces which are surfaces having only one color. The block matching algorithm would fail to reconstruct these surfaces because it depends on color difference between two square blocks of one surface to reconstruct depth. The mechanisms of some state of the art depth cameras such as Microsoft Kinect were used as references to solve this problem. Eventually, we decided to use a projector to project random patterns onto the target objects so that the surfaces can be reconstructed with the projected patterns. Tested with real-world environments and proven with improved result, my honor thesis was finished with a successful defense and a complete dissertation. I really appreciate such an independent research opportunity in my undergraduate study given by my advisors. It allows me to go through crucial steps to conduct fruitful researches: careful literature review, rigorous results comparison, persistent engineering and creative problem-solving.

Junior year finished honor thesis

I did not stop my exploration of 3D reconstruction after completion of my honor thesis. To be used as reconstruction component of my augmented reality pipeline, the depth reconstruction pipeline needs to be real-time. I started to learn about graphic processing unit (GPU) programming with CUDA and tried to convert the heavy computation my program onto multi-threaded GPU to reduce computation time. I also