**CHAPTER 5**

**DISCUSSION, CONCLUSION AND FUTURE WORK**

**5.1. Discussion**

In this thesis, a points feature matching technique based on RANSAC paradigm has been adopted to stabilize shaky videos. Finding the feature points using FAST corner detection algorithm in each frame we estimated the motion between the subsequent frames and then video frames have been warped to remove the jitters. The resolution of 650x364 pixel and 30 frames per second of the video sequences are stabilized with various smoothing radius using the explained algorithm. The quality of the output videos are varied according to the smoothing radius.

The MATLAB and FPGA results are most closely resembled each other. The qualities of the stabilized videos are same in both platforms. The differences between these two platforms are color available, processing power and installation in practical used. The MATLAB simulation can give only black and white result in the output videos. The colorful output results are available in the stabilized video in FPGA platform. The speed of the MATLAB simulation is only depended on processing system of the computer. So, the demand of the processing power for the real time video stabilization is too much. In FPGA, both processing system and programmable logic can be used. So, the demand of the processing power in FPGA does not need to worry. The last difference is the installation for practical used. As the MATLAB is simulation software for personal computer (PC), it cannot be implemented for practical used. The strong point of the FPGA is that it can be install in everywhere. It is small enough, low power consumption, available plug and play devices and it can be used in various application and can be mounted many related devices.

**5.2.** **Conclusion**

Video processing applications are used in many areas such as consumer electronics and military areas. Every video processing application has its own initial requirement from the input video such as video format, resolution and frame rate, but

the common requirement for all applications is the stabilization. Because, the translational and rotational changes in frame sequence cause faulty results in processing algorithms. Therefore video stabilization is the first and necessary step for other video processing applications.

Most of the systems use mechanical stabilization because these types of stabilizers prevent the undesired motion at the detector of the camera, so there will be no image loss. However, mechanical approach is not feasible for all platforms due to its huge and complex structure. Therefore, digital stabilization methods can be used as an alternative. Digital methods calculate the undesired motion by comparing two neighbor frames in the sequence. This comparison process requires long computation time and digital methods are not preferable in real time applications.

The recent advances in hardware elements, such as FPGAs, can handle the high computational load. The parallel structure of FPGA is configured in order to process many data at the same time. However, only FPGAs are not enough for all video stabilization flow, some other elements such as video decoders and encoder are required to construct a full system.

Firstly, the hardware that the digital video stabilization will be implemented is selected. Due to its high computation capacity, FPGA is chosen as a processing unit. The necessary video input & output, memory interfaces are constructed in FPGA. Then, the possible stabilization algorithms in literature are searched. Digital video stabilization based on points feature matching technique is selected as a solution candidate. That method is implemented in MATLAB to see its performance before FPGA coding. Since, the final implementation will be in FPGA, the MATLAB codes are written similar to FPGA. This approach provides more realistic comparison between the two platforms. After that, the FPGA (C++ in Vivado HLS, Block design and python codes in jupyter) codes are written for that method and complied for the FPGA on the main board.

The FPGA implementation results show that the points feature matching technique is reasonable and it can produce clearly stabilized videos at its outputs while MATLAB can also reach similarly to the FPGA’s performance. This is because of A9 processor’s performance which is build up in FPGA (PYNQ). Normally, FPGA can do the high computational load and can run parallel at the same time; it can work only in programmable logic side. The PYNQ, the FPGA which is used in this thesis, is a class of programmable System on Chip (SoC) which integrates a multi-core processor (PS) and a Field Programmable Gate Array (FPGA) (PL) into a single integrated circuit. Not all functions are written in PL. Some functions are run in PL and some are run in PS. So the performance of the implementation in FPGA is not as fast as it can afford.

To conclude, the implementation and comparison results show that, FPGAs are capable to run digital video stabilization method. FPGA results are the best in smoothing radius 50 pixel both x-direction and y-direction which is similar in MATLAB. The comparison between simulation and MATLAB results shows that FPGA can also reach the desired accuracy.

**5.3.** **Future work**

In this thesis, the digital video stabilization based on points feature matching technique is implemented by using the input file system. In the future, real time video stabilization system will be implemented on FPGA.