

# Chapter 6

## Conclusion and Future Work

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*In this chapter the dissertation is concluded with a quick overview of the research done, followed by the objectives that were achieved, the contributions that were made and a summary of the test result interpretations. Recommendations and ideas for future work are made at the end of the chapter.*

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### 6.1 Conclusion

In this dissertation the work that was done to create a novel video fingerprinting system was presented, from background to the implementation and on to the testing of the system. From the tests we concluded that the system does work properly for the environment it was intended for, detecting advertisements in real-time while being robust to some light distortions.

In this section the objectives that were achieved and the contribution this dissertation makes will be clearly stated. Afterwards, a summarization of the interpretation of the test results will be given as most of the results were discussed in Chapter 5.

### 6.1.1 Objectives achieved

In Section 1.3, the objectives for this research was laid out. All these objectives were achieved and they are listed below:

- **Research video fingerprinting:** The existing video fingerprinting techniques were researched and understood. Techniques from other fields like image processing and database structures were also successfully studied. All this information and knowledge was used to design the new video fingerprinting algorithm presented in this dissertation.
- **Develop new technique:** A new video fingerprinting technique was developed that can detect key frames in a video stream and create fingerprints for them that can be quickly saved or matched to a database. The conceptual idea was based on detecting key points in frames and creating hashes that characterise them. The quick detection of hashes in the database allows the system to run in real-time.
- **Implement and test algorithm in software:** The system was successfully implemented in the Visual Basic (VB) development environment. Tests were run on the implemented system and the results show that the system functions correctly.

### 6.1.2 Contribution

The main contribution of the work done in this dissertation is the novel technique that was designed to be used for broadcast monitoring. With new techniques peoples' minds expand to see new possibilities and hopefully this work will inspire someone to improve an existing technique or design one that can surpass all the existing ones.

The system was also implemented in the .NET environment and can run in real-time on a normal personal computer. The speed of the system is very fast, compared to other existing techniques. Most of the credit for the system's speed can go to the simple, but fast KFD that was developed during this research. KFDs haven't been used that much

in video fingerprinting systems and hopefully this dissertation shined some light on the importance of these techniques. If smarter and faster KFDs can be developed, video fingerprinting systems can be greatly improved.

The use of key points to fingerprint frames was also introduced with this research. This idea has a lot of potential and may be used in other new techniques that rely on key points, for example constellation fingerprinting recommended in Subsection 6.2.3.

Lastly, this research gives a deeper understanding of video fingerprinting through the background and existing techniques that was presented in this dissertation.

### **6.1.3 Interpreting the results**

If the results in Chapter 5 are seen as a whole and summarized, one can conclude that the novel video fingerprinting does function properly for its intended purpose of application. With the results from the first set of tests it was shown that the frame fingerprinting system does detect frames fast and efficiently and can withstand a certain amount of distortion. The KFD was then tested to see its efficiency and then combined with the frame fingerprinting to create the video fingerprinting algorithm. The video fingerprinting algorithm was tested and the main problem with detection was the key frame detector that did not detect enough key frames in some of the advertisements.

## **6.2 Recommendations for Future Work**

In this section all the ideas that were thought of, but not implemented because of time constraints, are mentioned to help anyone that might want to continue working on this problem.

### 6.2.1 Graphics Processing Unit (GPU) implementation

A lot has been said about the speed of a fingerprinting system in the dissertation, and although a video fingerprinting system was developed that runs in real-time, the execution time of the algorithm can be reduced even more by making use of a GPU while doing image processing. The GPU does calculations in parallel, effectively doing the same calculation on every pixel in an image at the same time, thus minimizing processing time. By using a GPU one can maybe even implement a very robust algorithm in real time.

### 6.2.2 Affine invariant key points

Another idea that can be researched, if one continues with the key point and hash idea for frame fingerprinting, is to use affine invariant key points. This will make the hashes more robust against affine image transformations that are very common if videos are displayed with different aspect ratios. Other candidate algorithms that extract key points from images may also be considered.

### 6.2.3 Fingerprint based on constellation

One idea that has been used in machine vision and pattern matching is the idea of matching a constellation of points to each other. If a pattern point matching can be developed that can work fast enough while fingerprinting and matching, it can work quite well to fingerprint frames using a key point detector like SIFT and probably improve robustness. Although the technique in this dissertation is a sort of constellation matcher in a way, as it checks the relationship between two key points and then saves it together, the points are still matched independently pair for pair and not seen as a whole constellation. If the whole set of key points' constellation could be matched quickly, this method can be used as a measure of difference between images and thus serve as a fingerprinting method for images.

### 6.2.4 High dimensionality reduction

While researching background theory for the problem of video fingerprinting, the subject of dimensionality reduction was discovered. In particular, the authors in [16] used LLE to create robust fingerprints for images. This idea may be useful in some video fingerprinting applications, especially if real-time detection isn't of utmost importance. The idea may even be expanded and applied to a video as a whole, thus treating it as a 3-dimensional object and reducing its dimensionality to detect it easily.

### 6.2.5 Improved real-time KFD

To improve detection rates of the fingerprinting system, the KFD can be improved. It is a difficult problem to create a robust KFD or SBD that works in real-time, and this may be a study all on its own.

### 6.2.6 Sectional or sequence fingerprinting

If real-time video detection isn't important in some instances, one may take a look at creating or improving a system that uses the shots in a video to create fingerprints. This may improve database efficiency and robustness, if done correctly.