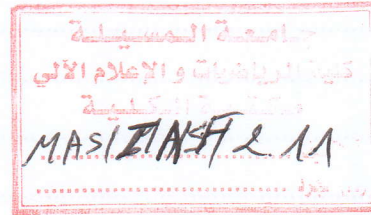


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TOPIC

**Design and Implementation of an Android
Application for Creating Panoramic Images**

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GENERAL INTRODUCTION

The last decade has been marked by the widespread of mobile devices. A typical example is the proliferation of Smartphones, which have been an integral part of the daily life of people. Besides their communication purpose, smartphones are used for entertainment, navigation, and as pick and shoot cameras among other things. They are quickly replacing advanced digital cameras, thanks to their processing capabilities and the quality of their sensors. Moreover, with the quick development of mobile operating systems such as Android and iOS, it is common now to find image processing applications that provide a lot of functionalities that used to be available only on desktops.

In this Master's thesis, we are going to design and develop an application for creating panoramic images that can run on Android smartphones. The aim is to take several pictures using the smartphone camera and then combine them to produce a picture that has a wider field of view than what can be taken by the on-board camera. The application is designed to help the user to take the best possible individual pictures.

The key idea to produce a combined picture is based on image stitching technique, where images are searched for correspondences between them, and then aligned according to these correspondences. A final blending processes is applied to smoothen the artificial stitching marks. Image stitching is a well-known technique used in domains such as robotics, astronomy and medical imaging.

This thesis is comprised of four chapters, organized as follows:

- **Chapter 1 (Overview of domain and state of art):** We review the fundamentals of the Android OS. We will also review work related to panoramic imaging and image stitching.
- **Chapter 2 (Image stitching):** we will go through the principals of image stitching with more details. In this chapter, we will explain image features and see two popular feature extraction methods: SIFT (Scale-Invariant Feature Transform) and SURF (Speeded Up Robust Features).
- **Chapter 3 (Implementation and Design):** in this chapter, we give the details of our application design and implementation. We will show the UML diagrams

of the different java classes as well as the interfaces and different parameters used to control the internal algorithms used by the application.

- **Chapter 4 (Tests and Results):** in this chapter, we show results of running our application on some data sets and discuss the obtained performance. The data sets represent pictures taken under different conditions (indoors. Outdoors. Lighting,...etc.).

CHAPTER 1:

OVERVIEW OF DOMAIN AND STATE OF ART

REFERENCES

Bibliography:

- [1] N. McCarthy, "Digital Cameras Are Getting Ditched For Smartphones," Shutterfly, 8 Dec 2014. [Online]. Available: <https://www.statista.com/chart/3036/digital-cameras-are-getting-ditched-for-smartphones/>.
- [2] tutorialspoint.com. [Online]. Available: http://www.tutorialspoint.com/android/android_architecture.htm.
- [3] "netmarketshare," Net Applications.com, April 2016. [Online]. Available: <https://www.netmarketshare.com/operating-system-market-share.aspx?qprid=8&qpcustomd=1>. [Accessed mai 2016].
- [4] E. Locardi. [Online]. Available: <http://www.blamethemonkey.com/hdr-photography-panorama-tutorial>.
- [5] D. Knight, "Top Panorama Problems and How to Solve Them," 2008. [Online]. Available: <http://www.theperfectpanorama.com/articles/problem-4-stitching.html>.
- [6] "Gobi Tripod BUNDLE," bushman-panoramic, [Online]. Available: <http://bushman-panoramic.com/bundles/gobi-bundle.html>. [Accessed 2016].
- [7] "FACEBOOK SURROUND 360 CAMERA," MMXV UNCRATE, LLC, [Online]. Available: <http://uncrate.com/stuff/facebook-surround-360-camera/>.
- [8] E. HUTCHINGS, "Unlock A Smartphone Just By Looking At It," psfk.com, 2012. [Online]. Available: <http://www.psfk.com/2012/07/face-recognition-iphone-lock.html>. [Accessed 2016].
- [9] L. Bedigian, "5 Of The Coolest Gesture Control Devices," Benzinga, 2014. [Online]. Available: <http://www.benzinga.com/top-stories/14/09/4880572/5-of-the-coolest-gesture-control-devices>. [Accessed 2016].
- [10] "Register an Aerial Photograph to a Digital Orthophoto," mathworks, [Online]. Available: <http://www.mathworks.com/help/images/register-an-aerial-photograph-to-a-digital-orthophoto.html>. [Accessed 2016].
- [11] D. Yining and Z. Tong, "Generating Panorama Photos," Hewlett-Packard Labs, 1501 Page Mill Road, Palo Alto, CA 94304.
- [12] P. Krishna, *Stitching of X-ray Images*, Box 536 751 21 Uppsala: Uppsala University, November 2012.
- [13] F. M. Schaukowitsch, "An interactive application for camera calibration, image stitching and projective operations," Vienna, 2013.
- [14] D. G. Lowe, "Distinctive image features from scale-invariant keypoints," *International journal of computer vision*, vol. 60, no. 2, pp. 91-110, 2004.

REFERENCES

- [15] [Online]. Available: <http://www.di.ubi.pt/~agomes/cvm/teoricas/05-edgedetection.pdf>.
- [16] A. SEDAGHAT and H. EBADI, "VERY HIGH RESOLUTION IMAGE MATCHING BASEDON LOCAL FEATURES AND K-MEANS CLUSTERING," no. 30, p. 166–186, June 2015.
- [17] H. Bay, T. Tuytelaars and L. V. Gool, "Speeded-up robust features (SURF)," *Computer vision and image understanding*, vol. 110, no. 3, pp. 346-359, 2008.
- [18] E. Oyallon and J. Rabin, "An Analysis of the SURF Method," Image Processing On Line.
- [19] "Introduction to SURF (Speeded-Up Robust Features)," OpenCV, [Online]. Available: http://docs.opencv.org/3.0-beta/doc/py_tutorials/py_feature2d/py_surf_intro/py_surf_intro.html.
- [20] L. Juan and O. Gwun, "A Comparison of SIFT, PCA-SIFT and SURF," *International Journal of Image Processing (IJIP) Volume(3), Issue(4)*.
- [21] A. Olić, "Introduction to Gradle," [Online]. Available: <https://semaphoreci.com/community/tutorials/introduction-to-gradle>. [Accessed 2016].
- [22] "Fast Panorama Stitching," Intel Corporation, 2014. [Online]. Available: <https://software.intel.com/en-us/file/fast-panorama-stitchingpdf>.
- [23] "Low-pass filter," Wikipedia, [Online]. Available: https://en.wikipedia.org/wiki/Low-pass_filter.
- [24] E. Adel, M. Elmogy and H. Elbakry, "Image Stitching based on Feature Extraction," *International Journal of Computer Applications Volume 99– No.6, August 2014*.
- [25] M. Brown and D. G. Lowe, "Automatic panoramic image stitching using invariant," *IJCV*, 2007.
- [26] P. Mayani, "Introduction to Android Studio," October 2013. [Online]. Available: <https://dzone.com/articles/introduction-android-studio>. [Accessed 2016].

Abstract

In this document, we have discussed the subject of creating an application for smartphones on Android system, that can generate panoramic images (photos with a wide angle of view). We have done some experiments and researches on algorithms and methods of image stitching, and calculation required to do the work. We studied these methods with considering the limitations of smartphone performance. The results of our work are panoramic images with high quality, which consumes some time to be produced and other normal or low quality panoramas that does not require too much time, and this is by providing multiple settings for the user to choose from, whether it was just an ordinary user or a professional photographer.

ملخص

في هذه المذكرة ناقشنا موضوع إنشاء تطبيق للهواتف الذكية على نظام الاندرويد يقوم بعمل صور بانورامية (ذات زاوية رؤية واسعة)، حيث قمنا ببعض التجارب والبحوث حول الخوارزميات وطرق تخطيط الصور والحسابات المطلوبة للقيام بهذا العمل، ثم درسنا ذلك باعتبار محدودية الهواتف الذكية في الأداء، وقمنا بإنتاج صور بانورامية بجودة عالية التي تستهلك الكثير من الوقت ليتم انتاجها وأيضا صور اخرى متوسطة التي لا تأخذ وقت كبيراً، وهذا بتوفير عدة إعدادات للمستخدم ان يختار منها سواء كان مجرد مستخدم عادي أو مصور محترف.

Résumé

Dans ce mémoire de master, nous avons discuté le sujet de la création d'une application pour les Smartphones sur le système Android qui peut générer une des images panoramiques (photos avec un grand angle de vue), Nous avons étudié des algorithmes et des méthodes de couture d'images et le calcul nécessaire pour faire le travail. alors, nous avons étudié avec tenant compte des limites de Smartphone dans la performance, nous avons atteint pour réaliser des images panoramiques de haute qualité, qui consomme beaucoup de temps à produire et à d'autres panoramas de qualité normale, et ceci est en fournissant de multiples paramètres pour l'utilisateur de choisir, si il était juste un utilisateur ordinaire ou un photographe professionnel.