

بِسْمِ اللَّهِ الرَّحْمَنِ الرَّحِيمِ

**قال تعالى:**

وَأَمَّا هَآءِ الْيَنْفَعُ النَّاسَ فِيهِ كَثٌ فِي الْأَرْضِ

صدق الله العظيم

الرحمة ١٧

# DEDICATION

To

My dear mother and spirit of my dear father

My brothers and my sisters

My Wife

Light of my eyes, my kids Mohammed and Mahmoud

My Large Family

And my friends

## **ACKNOWLEDGEMENT**

Many thanks to all who contributed in the completion of this work, and especially thanks to:

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# ABSTRACT

The ability of thermal cameras to produce a crisp image even in total darkness and to measure objects temperature by special calibration in a non-contact mode makes them extremely suitable for a wide variety of applications. The objective of this thesis is to design high performance, simple structure, and low cost IR optical system (IR lenses) to work compatible with IR113 thermal detector module in order to obtain high quality thermal images, followed by thermal images processing software to build thermographic camera suitable for many civilian applications (early detection of breast cancer as medical application).

ZEMAX optical design program was used to design, optimize, and meet the targeted criterion (lower MTF value at cutoff frequency = 0.583348, and maximum value of spot diameter =  $8.805\mu\text{m}$ ) of an IR optical system which consists of 3 germanium lens with one aspheric surface, and it was characterized by diameter of 40mm, length of 58.5mm, and weight of 70g. The manufacturing of this optical system was done in company specializing in production of IR optical systems at reasonable cost.

6061 aluminum alloy was used to manufacture special mechanical case to assemble (carry and align) the optical system with thermal detector module and build handheld thermal camera. This camera (IR optical system+ thermal detector module) was tested in field by taken several thermal images.

MATLAB computer software was used to create PC thermal image processing software to convert the thermal gray images to flash color images and read the object temperature from its image. The thermographic camera was tested by read temperature of objects from its images and compared them with known in advance temperatures and we get acceptable results.

## المستخلص

قابلية الكاميرات الحرارية لإنتاج صور واضحة حتي في الظلام الدامس و لقياس درجة حرارة الاجسام بمعايرة خاصة في وضع عدم الاتصال يجعلها مناسبة للغاية لعدد كبير من التطبيقات. اغراض هذا البحث هي تصميم نظام بصري (عدسات) للاشعة تحت الحمراء عالي الاداء، بسيط البنية، ومنخفض التكلفة ليعمل متوافقاً مع وحدة الكاشف الحرارى IR113 وذلك للحصول على صور حرارية عالية الجودة متبوعاً ببرنامج لمعالجة الصور الحرارية من اجل بناء كاميرا رسم حرارى ملونة (thermographic camera) مناسبة لكثير من التطبيقات المدنية.

برنامج التصميم البصري ZEMAX تم إستخدامة لتصميم وتحسين و تلبية المعايير المستهدفة (اقل قيمة لدالة نقل التضمين MTF عند تردد القطع = 0.583348 و اقصى قيمة لقطر البقعة = 8.805 ميكرومتر) لنظام الاشعة تحت الحمراء البصري المكوّن من ثلاثة عدسات جرمانيوم مع سطح واحد شبه كروي (aspheric surface)، والذي يتميز بقطر 40 ملم و طول 58.5 ملم و وزن 70 جرام. تم تصنيع هذا النظام البصري فى شركة متخصصة في انتاج هذا النوع من الانظمة البصرية بتكلفة معقولة.

سبيكة الالمونيوم 6061 إستُخدمت لتصنيع هيكل ميكانيكى خاص لتجميع (حمل و محاذاة) النظام البصرى مع وحدة الكاشف الحرارى وبناء كاميرا حرارية محمولة يدوياً . هذه الكاميرا (نظام الاشعة تحت الحمراء البصري+ وحدة الكاشف الحرارى) خُبِرت ميدانياً براخذ عُدّة صور حرارية.

برنامج MATLAB تم إستخدامة لإنشاء برنامج حاسوبي لمُعالجة الصور الحرارية لتحويل الصور الحرارية الرمادية لصور حرارية ملونة وقراءة درجة حرارة الجسم من صورته. تم إختبار كاميرا الرسم الحرارية بقراءة درجة حرارة الاجسام من صورها الحرارية و مقارنتها بدرجات حرارية معلومة سلفاً و تحصلنا علي نتائج مقبولة.

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## LIST OF ABBREVIATIONS

Objective Name	Description
PC	Personal Computer
MTF	Modulation Transfer Function
FPA	Focal Plan Array
CCD	Charge Coupled Device
LLL TV	Low Light Level Television
MWIR	Medium Wave Infrared
LWIR	Long Wave Infrared
ADD	Airy Disk Diameter
FOV	Field Of View
WFOV	Wide Field Of View
TOTR	Total Track
EFFL	Effective Focal Length
HDD	Horizontal Detector Dimension
VDD	Vertical Detector Dimension
HFOV	Horizontal Field Of View
VFOV	Vertical Field Of View
MRTD	Minimum Resolvable Temperature Difference
NETD	Noise Equivalent Temperature Difference
RMS	Root Mean Square