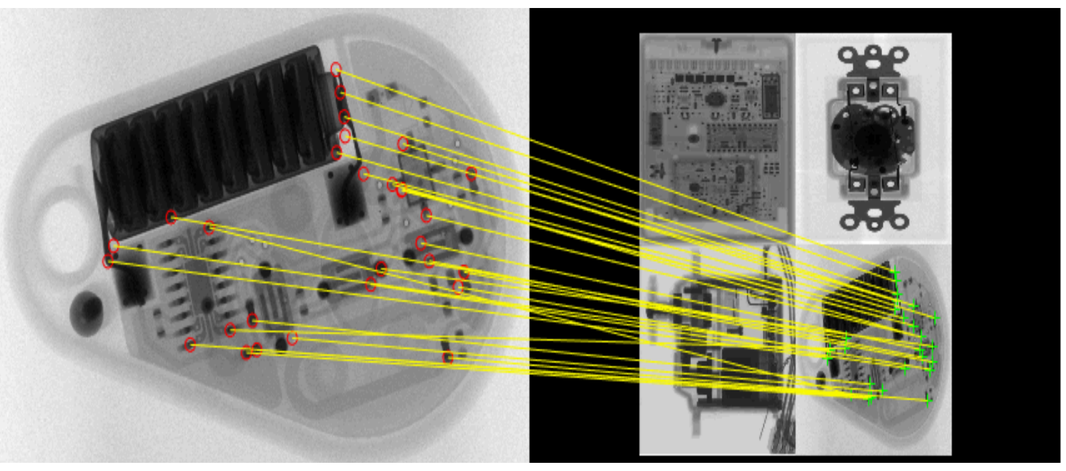
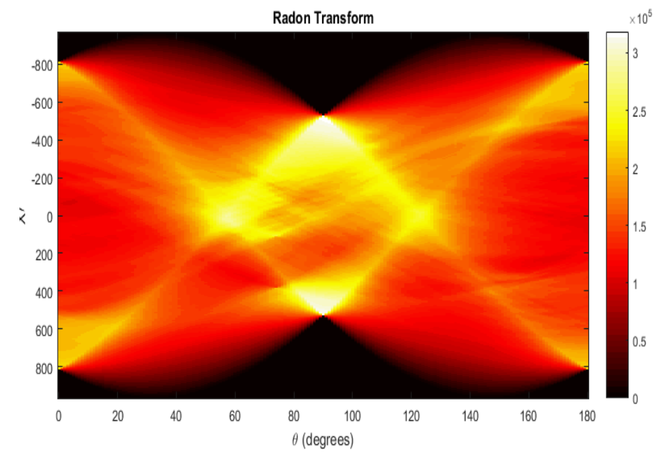
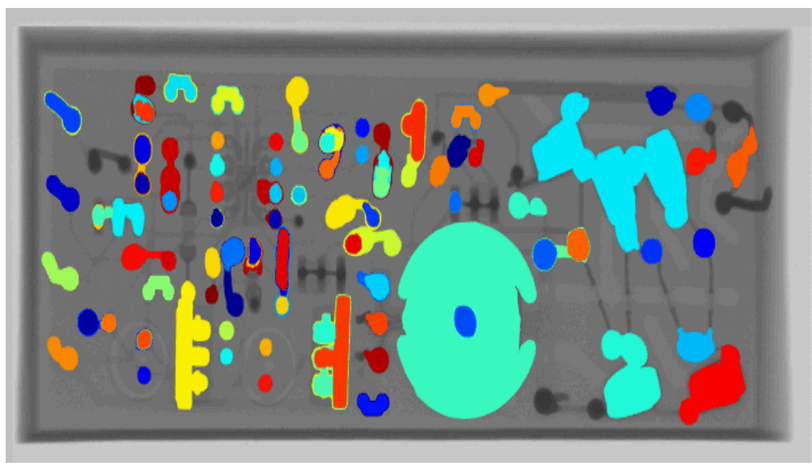
SAND2016-6905C

Exceptional service in the national interest

Sandia National Laboratories







Object Recognition in X-ray Images

Joshua A. Vita
The University of Arizona, Tucson
B.S. in Materials Science and Engineering, B.S. in Mathematics, May 2017
Sandia National Laboratories/NM Org. 9525, U.S. Department of Energy
Manager: Judith E. Spomer; Mentors: Andrew C. Wantuch, Dr. Edward S. Jimenez

Abstract

Common obstacles to object recognition include transformations such as scaling, rotation, noise, occlusion, and changes in illumination. Many of these issues are further amplified by the unique properties of X-ray images. While some of these problems can be resolved using conventional object recognition and image processing techniques, others will require more advanced methods. This work not only demonstrates the capabilities of some pre-existing software packages, but also explores alternative concepts and their applications to X-ray images.

Introduction

The development of an accurate and efficient object recognition program requires the cooperation of two major components: computer vision and image processing. Computer vision refers to how a computer acquires and analyzes images and other forms of data. Image processing is the manipulation of images to streamline the extraction of useful data. In the case of object detection, image processing can help resolve some of the typical problems that an object recognition program will face, such as a cluttered environment or the presence of noise.

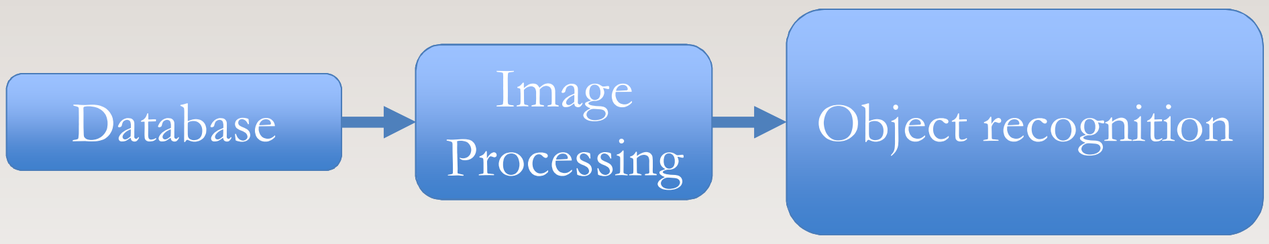


Figure 1: Databased images must be cleaned with image processing techniques before being passed to the object recognition algorithm.

While many toolboxes already exist for image processing and object recognition, a robust program that incorporates both of these features and that is capable of working specifically with X-ray images has yet to be created. Along with these software packages, significant research has been done concerning object recognition in X-rays, but no universal answer has been found. The goal of this project is to develop a robust object recognition algorithm capable of using a database of X-ray images to detect various anomalies in a given test image. Success will result in disruptive repercussions in many areas such as identification of tumors in cancer patients, anomaly detection in airport security, and analysis of industrial processing procedures. The key to this project will be to utilize the pre-existing software, to explore current theories in the field of object detection, and to develop solutions for the unsolved problems posed by X-ray images.

U.S. DEPARTMENT OF ENERGY
National Nuclear Security Administration

Sandia National Laboratories is a multi-program laboratory managed and operated by Sandia Corporation, a wholly owned subsidiary of Lockheed Martin Corporation, for the U.S. Department of Energy's National Nuclear Security Administration under contract DE-AC04-94AL85000.
SAND No. 2011-XXXXP

INFORMATION SOLUTIONS

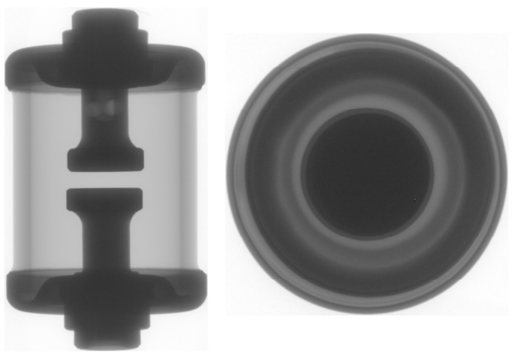


Figure 2: Though images can look drastically different depending on the viewpoint, X-ray penetration means that some useful information can still be conveyed.

Sandia National Laboratories

Exceptional service in the national interest

Background

Conventional object recognition techniques involve the use of feature descriptors. A "feature" could be a number of things, including a corner (Harris), a blob (SURF), or a region of uniform intensity (MSER). An important part of this project involves determining what features or combination of features will work best for our given database of images.

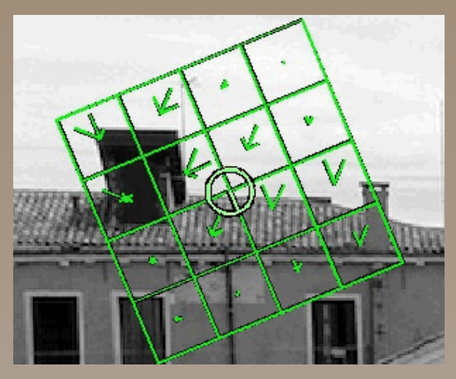


Figure 3: an example of a SIFT descriptor
Image from http://www.vlfeat.org/

Developmental Steps

1. **Experiment:** Assess the validity of current object recognition software as applied to X-ray images.
2. **Apply:** Establish a method that can deal with the simpler problems such as noise, illumination changes, rotations, and minor occlusions.
3. **Expand:** Improve the established process to create a complete algorithm capable of addressing the more complex issues including out-of-plane-rotations and superimposed objects.

Approach

Experiment:
1. Test available software (MATLAB, OpenCV).

Apply:
1. Determine the best processing techniques and feature extraction methods specifically for this database.
2. Apply the methods using software from Step 1.

Expand:
1. Evaluate weaknesses of algorithm from Step 2.
2. Experiment with advanced methods specific to X-rays.
3. Research and develop alternative methods.

Results

Current methods perform well under minor affine transformations (rotation, scaling, etc.) and illumination changes, but begin to deteriorate under severe transformations and the presence of noise.

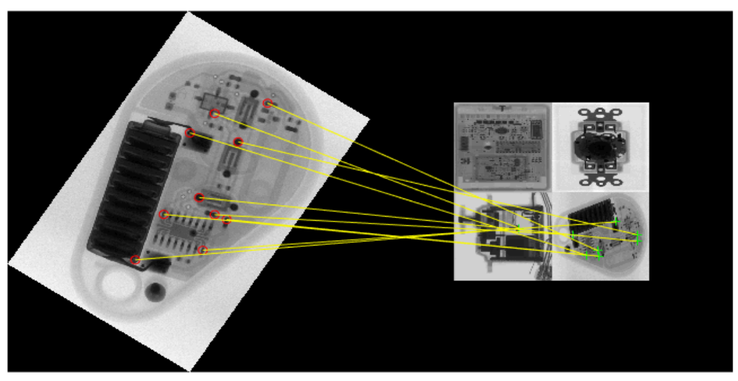


Figure 4 (left): A demonstration of the capabilities of pre-existing software when working with rotated images.

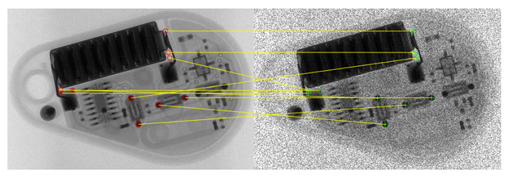


Figure 5 (above): Noise decreases the accuracy of matching algorithms; image processing is needed.

Conclusion

The project is currently in the second of the three developmental steps. Various software packages have been selected for implementation of the more common object recognition techniques. Testing shows that while these methods are a good starting point, work needs to be done to improve image quality with image processing, and combine or alter feature descriptors to create a more robust matching algorithm.

Future Work

- Improve on feature descriptors to account for out-of-plane rotations.
- Build 3D approximations of objects based on multiple viewpoints.
- Experimenting with different processing methods to handle superimposed objects.

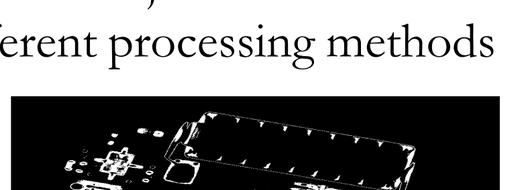


Figure 6: Segmentation is one of many processing methods that may prove useful.

U.S. DEPARTMENT OF ENERGY

National Nuclear Security Administration

Sandia National Laboratories is a multi-program laboratory managed and operated by Sandia Corporation, a wholly owned subsidiary of Lockheed Martin Corporation, for the U.S. Department of Energy's National Nuclear Security Administration under contract DE-AC04-94AL85000.
SAND No. 2011-XXXXP

INFORMATION SOLUTIONS