3D Object Recognition Under Perturbation of Orientation and Illumination

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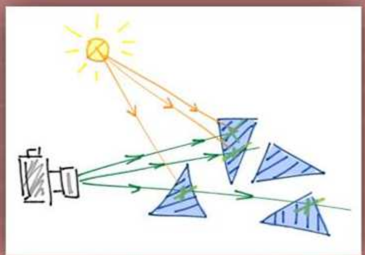
Background and Goal

Object recognition using machine algorithm is generally more complicated than using human sense due to the limitations such as variation of object observation view-point and illumination. The goal of this research is to build a system capable of recognizing polyhedral 3 dimensional object under perturbation of orientation and illumination by using feature-based artificial neural network.

Problems

In order for a camera to capture images of an object, every point on the object surface must reflect light of a certain intensity.



Depending on the level of light intensity, an object might cast different patterns of shadows and reflection. Object orientation with respect to observer viewpoint may also varied and distort the overall shape of the object observed. Both condition mentioned have a chance of causing misinterpretation in object recognition.

Most 3D object recognition method is computationally intensive. Therefore, the algorithm for each given system must be selected based on the problems encountered. This also applies to neural network architecture, as neural network architecture determines how a system should react to variation of input.

MAJOR INTEREST : Robotic System
TYPE : Research

Methods

In order to solve problem in question, the following experiment method is carried out:

1. **Image Pre-processing**
   Assuming that the camera's optical axis points to the center of rotating platform, only the center portion of the image needs to be processed. A 320x320 window is used to define the area of interest. Gray scaling is used to reduce processing time and SUSAN Edge Detector is used to detect edges. The resulting edge is thinned using Non-Maximum Suppression.

2. **Image Processing**
   The descriptor making process is simplified by extracting the edge image obtained into several parts. This is done by differentiating the edge pixels connectivity. Each part will then be translated into lines of data representation featuring the distance between each edge pixel from the image center of gravity.

3. **Recognition**
   Each descriptor will be fed into a different neural network. Therefore, the output combination of these network needs to be considered when determining the object in question. The training process is carried out using back propagation learning algorithm with adaptive learning rate. Each network use an ANN architecture of 2000-2-2.

Experiment Setup

The system is built using MATLAB with Image Processing and Neural Network Toolbox. Logitech Webcam c170 series is used to capture image with a resolution of 640x480 pixels. The object observed will be placed on a rotating platform so that images can be taken from different point of views. Images of each object will be taken every 5 degree rotation. Images taken from angles divisible by 15 will be used for training while the rest of the images will be used for testing. Robustness against illumination will then be tested using various light intensity ranging from 100 to 1000, with a +50 lux tolerance.

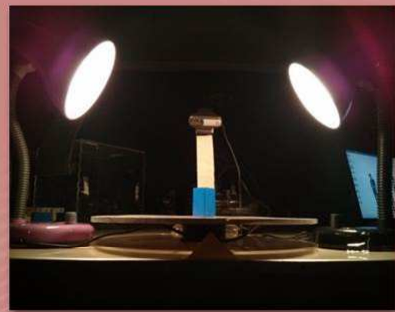


Figure 1 Experiment Setup

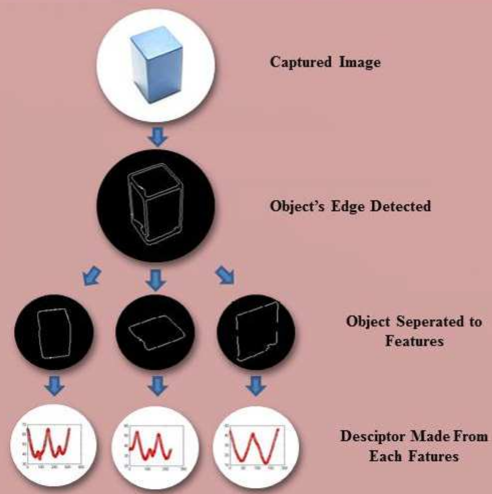


Figure 2 Experiment Steps

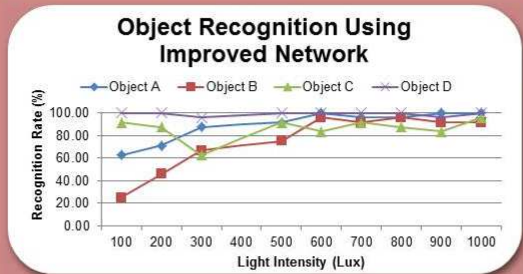


Figure 3 Recognition Results from Improved Network

Results

The best network configuration can be achieved using a combination of feature 1 and 2. The best network is obtained using training images taken at 800 lux, with network architecture of 1 hidden layer and 2 hidden layer nodes.

For object A and B, low light intensity causes a lower recognition rate. This is due to shadows forming around the object which alters the detected edge shape, causing discrepancy between the descriptors used for training and the ones used for testing.

In contrast to object A and B, discrepancy of edges due to low light intensity are not sampled during the descriptor making process of object C and D. Therefore the recognition rate of object C and D are relatively constant even at low light intensity.

Conclusion

- The system is able to achieve an average recognition rate of 94.79%.
- Network trained using images taken at 800 lux have a higher intesity tolerance.
- The 1st combination is the best feature combination that can represent the object in question.

References

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- Wilamowski, B. M. (2003). Neural Network Architectures and Learning. *ICIT 2003.*
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