CS5330 Final Project

Building A real-time Mirror/ Bilateral Symmetry Detector

Group Members:

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Presentation Record (If can't open, use the link in readme.txt file):
https://drive.google.com/drive/folders/124VMZ3OatByfEKc6tS1L3FCVn6vRsgul?usp=sharing

Project Overview

- Introduction
- Description of related work
- Method
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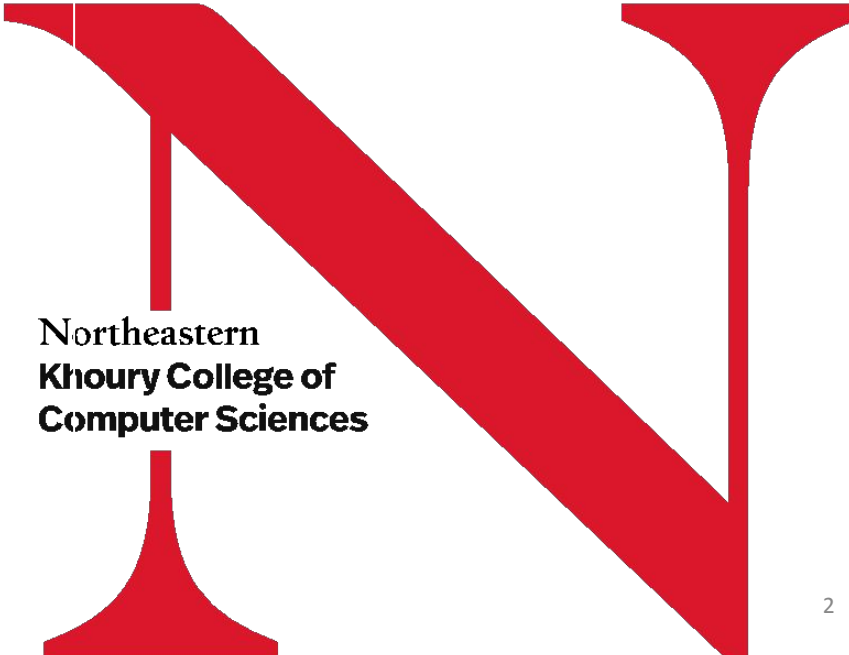
- Summary and future improvements



Introduction

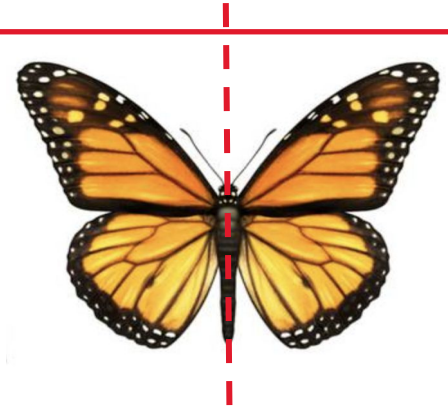
- **Mirror symmetry:**

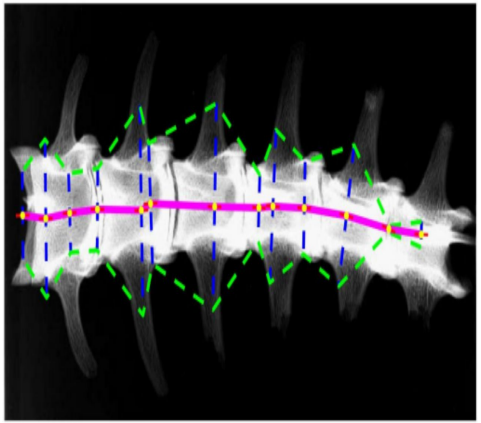
  a geometric property where a shape or pattern reflects identically across a central axis, creating a mirrored image.

- **Bilateral symmetry:**

  a biological characteristic in which an organism's body plan is divided into two equal halves along a central plane, with matching structures on both sides.

- **Application:**
  1. object recognition
  2. object classification
  3. region segmentation
  4. medical imaging





Introduction

- **Symmetry detection is hard**
  1. The symmetric axis of object is random
  2. Illumination variable is hard to predict
  3. some object may be partially covered
  4. Non-rigid deformations
- **Find features which isinvariant to rotation and translations**
  1. Scale-invariant feature transform (SIFT)
  2. Speeded up robust features (SURF)
  3. Histogram of oriented gradient (HOG)
- **Our project aim**

  we proposed a robust method to detect the mirror symmetry and bilateral symmetry in a still image or real-time live stream using SIFT features.

Description of related work

1. **Early use of feature matching methods to find symmetry**

   “Symmetry Detection Using Gradient Information” - C. Sun: Developed a method which obtain direction of symmetry axis by gradient orientation histogram and center, then decide the position of symmetry by center of gravity and image projection along the symmetry direction.

2. **Emerging of new robust feature algorithm**

   “Distinctive Image Features from Scale- Invariant Keypoints” - D. G. Lowe: presents the SIFT algorithm for extracting features from an image. The feature is invariant to image scale, rotation and provides a relatively robust matching in different images across illumination and viewpoints changes.

3. **New symmetry detection method proposed**

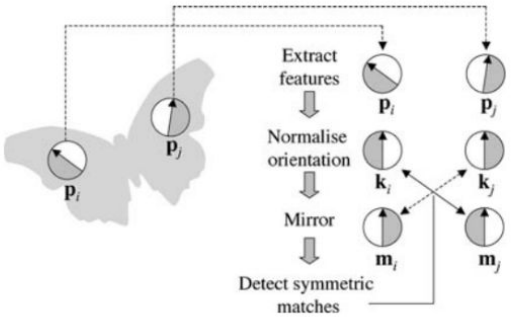
   “Detecting symmetry and symmetric constellations of features”- G. Loy and J.-O. Eklundh: create a novel method for grouping feature points based on their underlying symmetry and characterizing symmetries in an image.

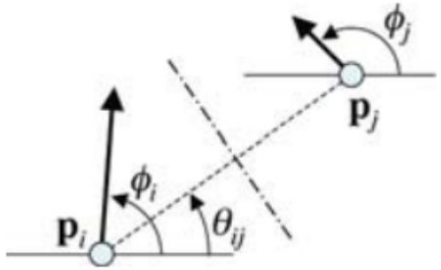
4. **Machine Learning/Deep Learning Method**

   “Discovering symmetry invariants and conserved quantities by interpreting siamese neural networks” - Wetzel, Sebastian & Melko, Roger & Scott, Joseph & Panju, Maysum & Ganesh, Vijay.:discovers symmetry Invariants and conserved quantities of image by introducing an interpretable Siamese Neural Networks (SNN) for similarity detection.

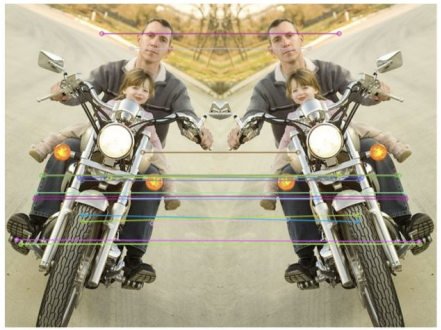
Method

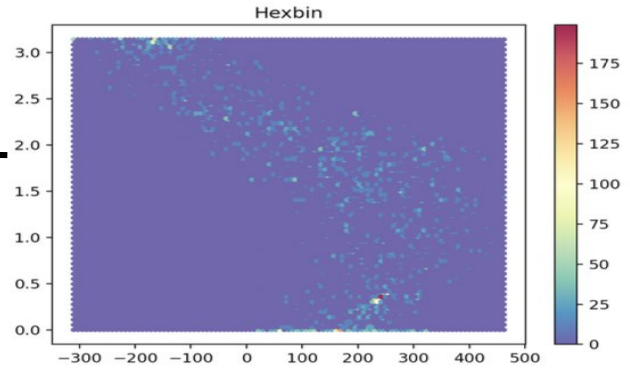
1. **Feature selection** : Scale-Invariant Feature Transform (SIFT)
2. **Features extraction from the image**: Extract SIFT features points and descriptors from original and mirror image
3. **Feature points matches**: utilized Brute Force Matcher with KNN algorithm to find matches.
4. **Calculation of potential mirror symmetry lines polar coordinates:** calculated by positions of matched pairs
5. **Draw a hexbin diagram**: Generate a hexbin plot using the polar coordinates of symmetry lines.
6. **Choose the dominant symmetry lines**: the hexagon with most vote dominates the main symmetry.
7. **Test our detector**: consists of 67 images (17 simple geometry or symbols images and 50 real photos).
8. **Make our detector recognize real-time live stream**: applied this detector in a real-time live stream.





Results - Analysis mode



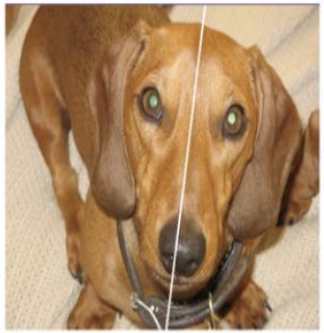


Results - Test Mode(1)

TABLE I. TEST RESULT

Image type	test condition		
	Number of images	*pass*	*accuracy*
Geometry images	17	17	100%
Photos	50	45	90%
All images	67	62	92.5%



Results - Test Mode(2)

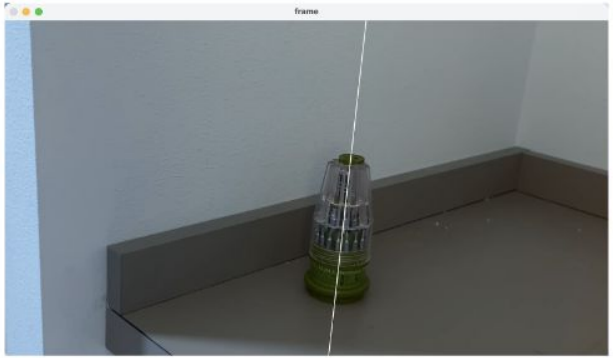
Potential reasons

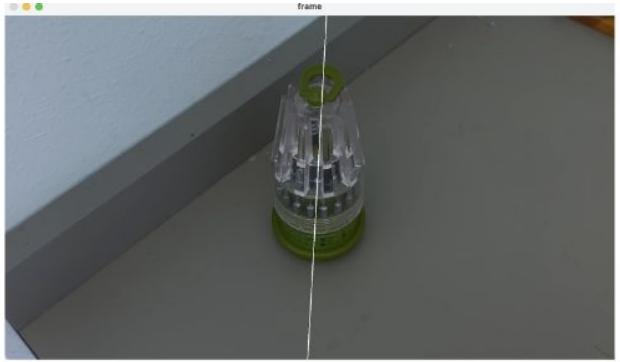
- Image is partially obscured
- The symmetry line is aligned with x axis
- Color of project is too similar with the environment.



Results - Real-time Mode

Detect the symmetry line for a symmetrical tool set in different translation, rotation and scale in a real-time live stream





LVX
VERITAS
VIRTVS

Summary and future improvements

Summary

- Our method of detecting mirror/bilateral symmetry demonstrates robust properties on both still image and real-time video
- It works perfectly with simple geometry images(100% accuracy) and good with most environment in the nature (90%)
- Has limitations when deal with covered objects, similar environments and perfectly x-axis aligned object

Future improvement:

- Explore alternative feature such as SURF
- Investigating more advance matching algorithms
- Incorporating machine learning techniques