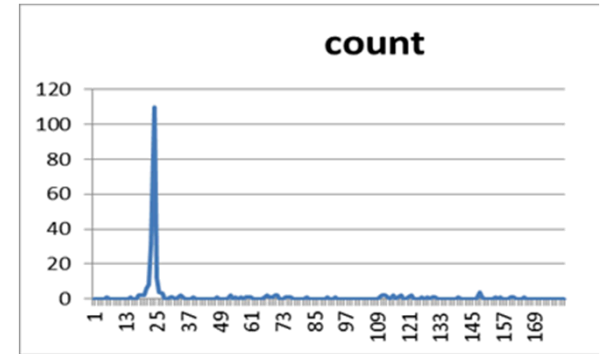
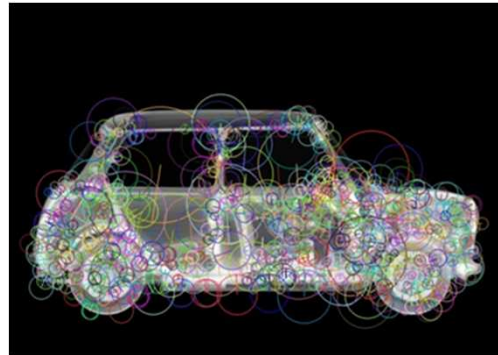
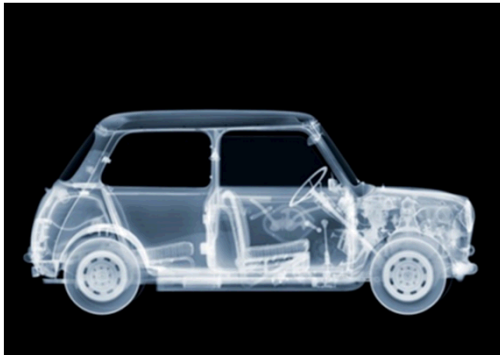


Exceptional service in the national interest



SURF Feature Matching Applied to Radiography

Charles Little, Chris Wilson

Workshop on Techniques for Protection of Imaging Information 06/01/2016

Image Matching

- Goal – find a target image in a set of reference images

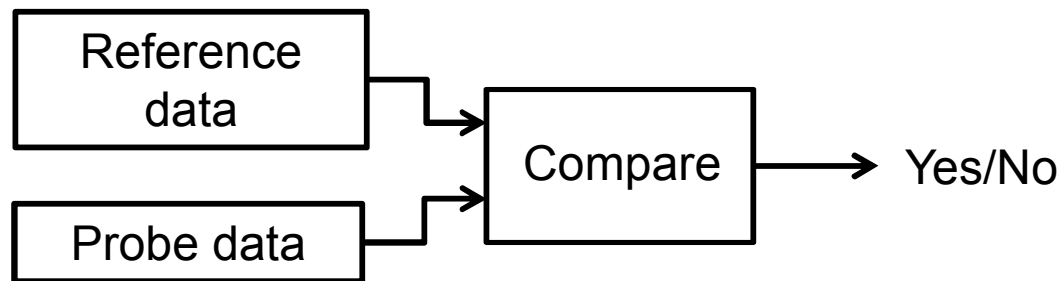
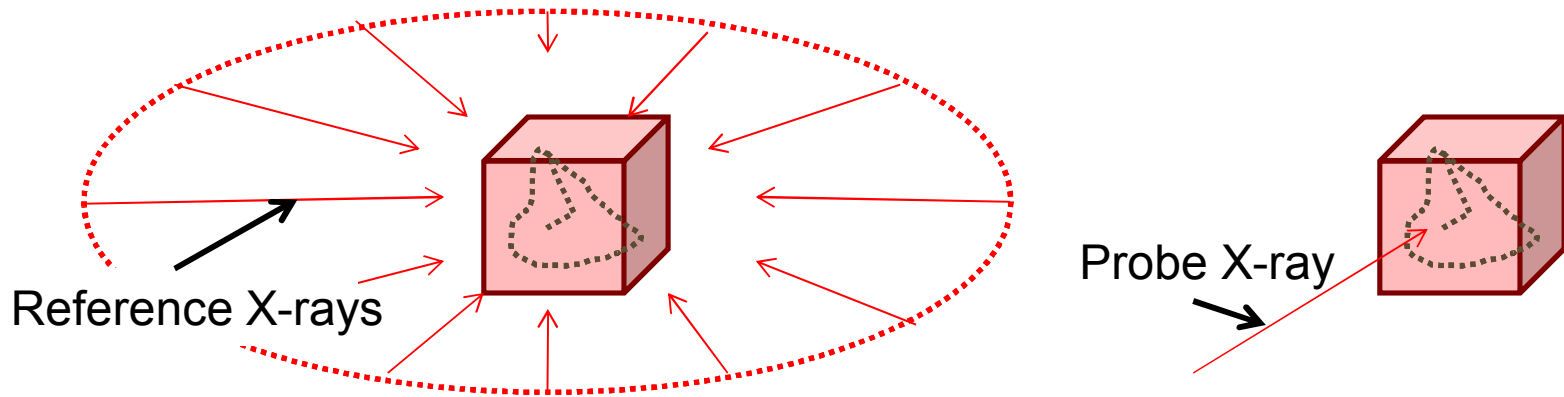
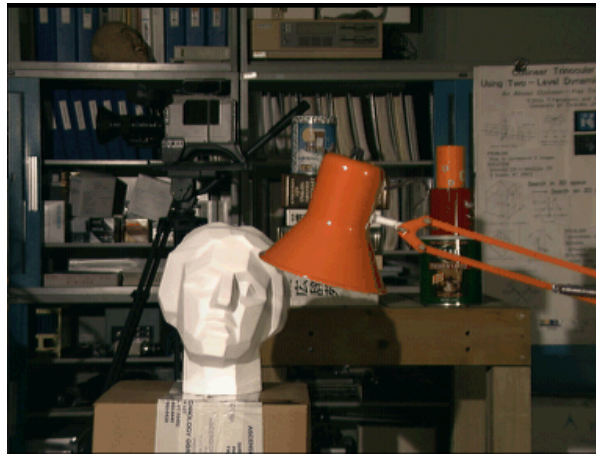
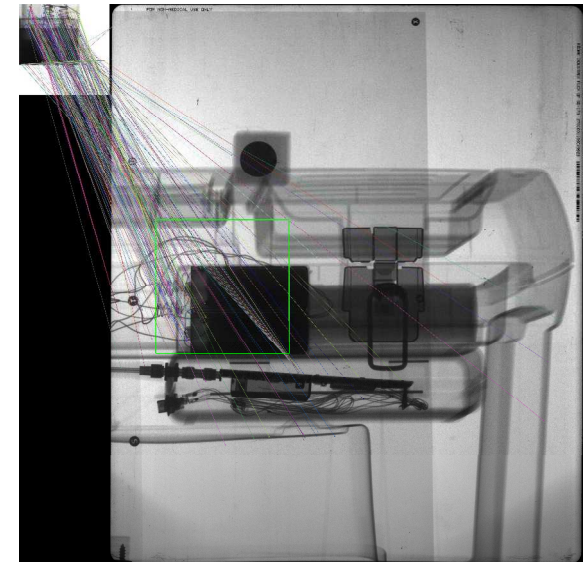


Image Matching -- Feature based matching

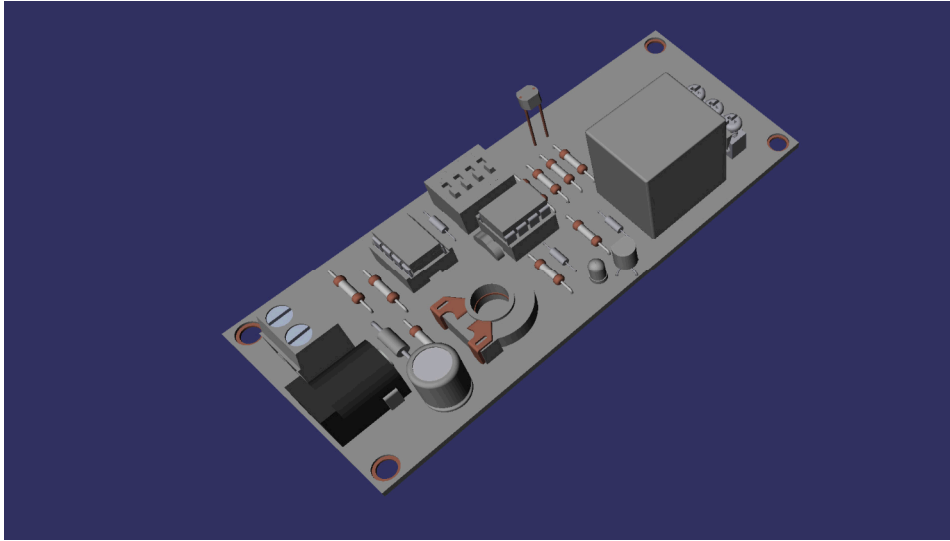
Match a target image to a reference image



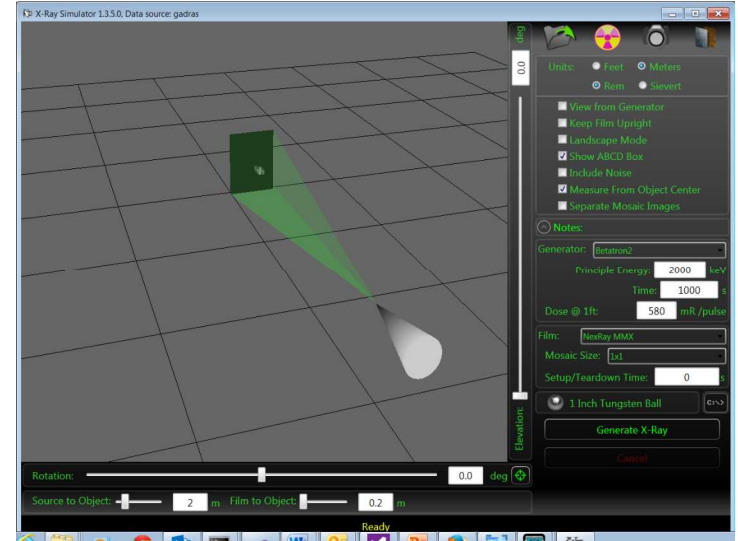
Can be scale and
rotation invariant



Radiography of CAD Models



CAD Model of timing circuit



X-ray simulator

X-ray
images

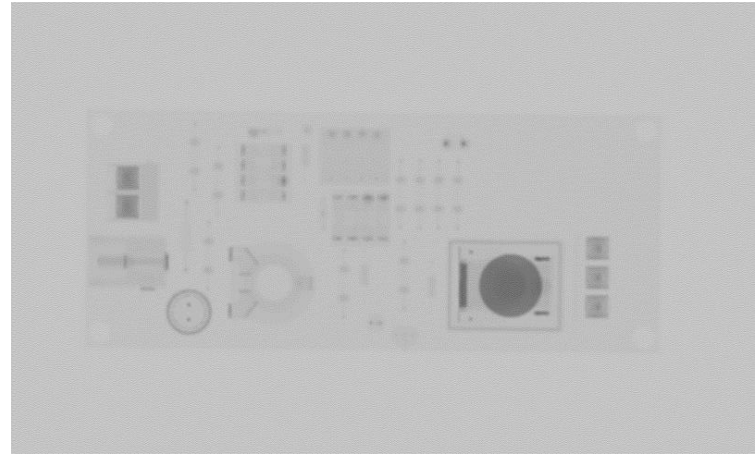
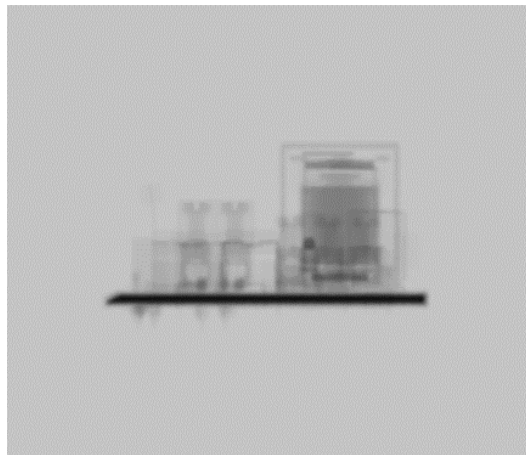
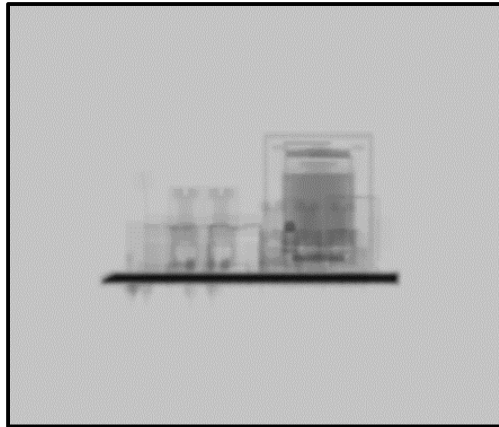
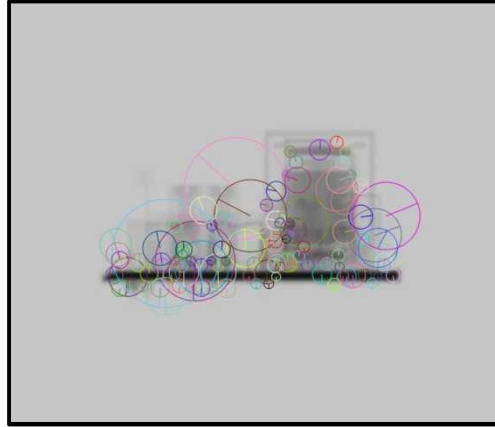


Image Matching -- Feature based matching

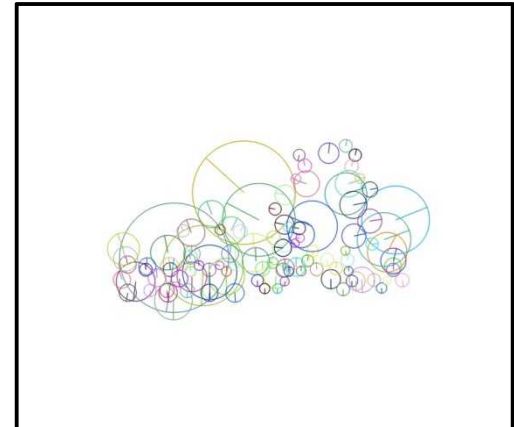
SURF based feature extraction



X-Ray



X-Ray with features



Features only

Features without
geometry

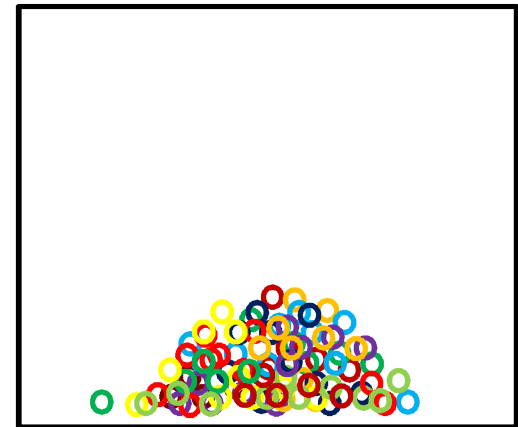
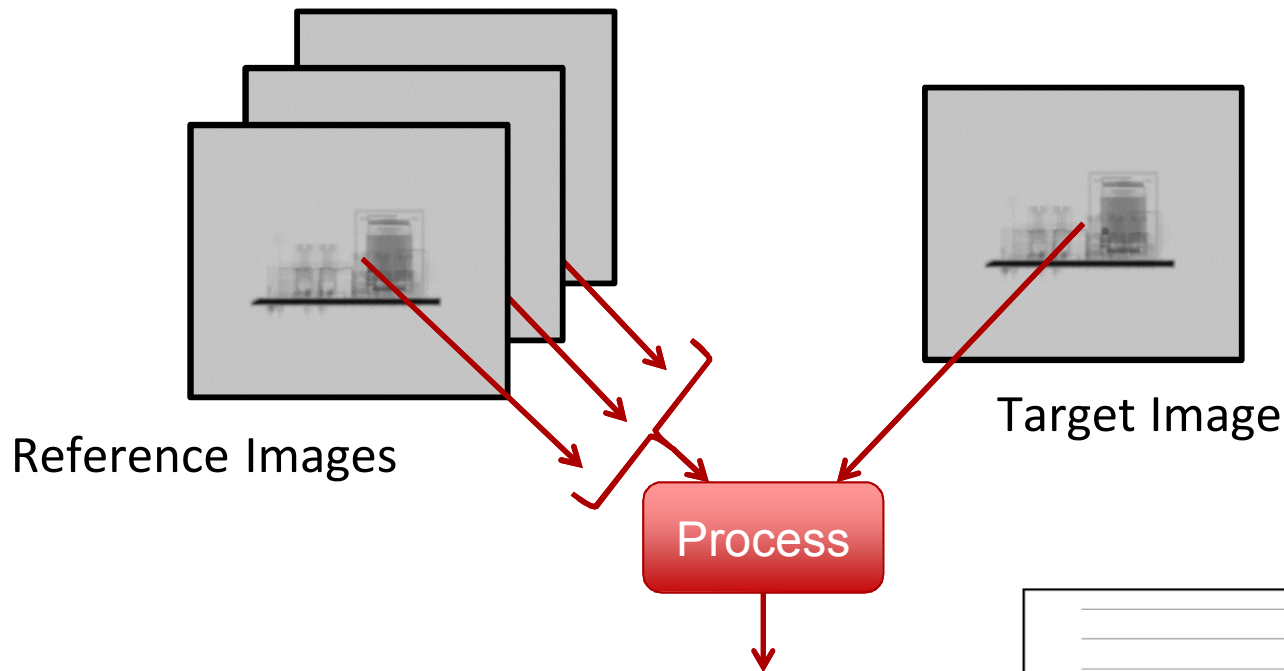


Image Matching -- Feature based matching

One-to-Many Matching



All reference image features collectively matched with the target image. Match value determined by which ref image has the most features that match the target

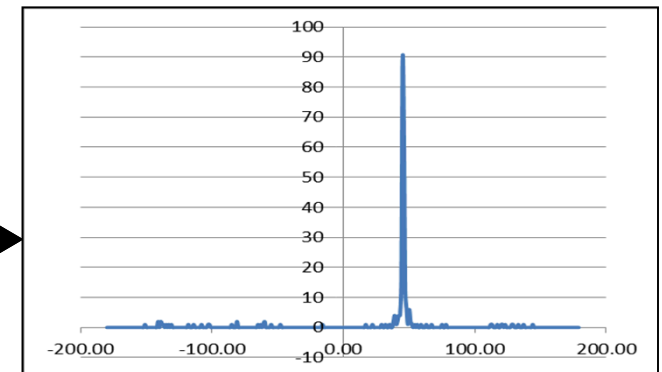
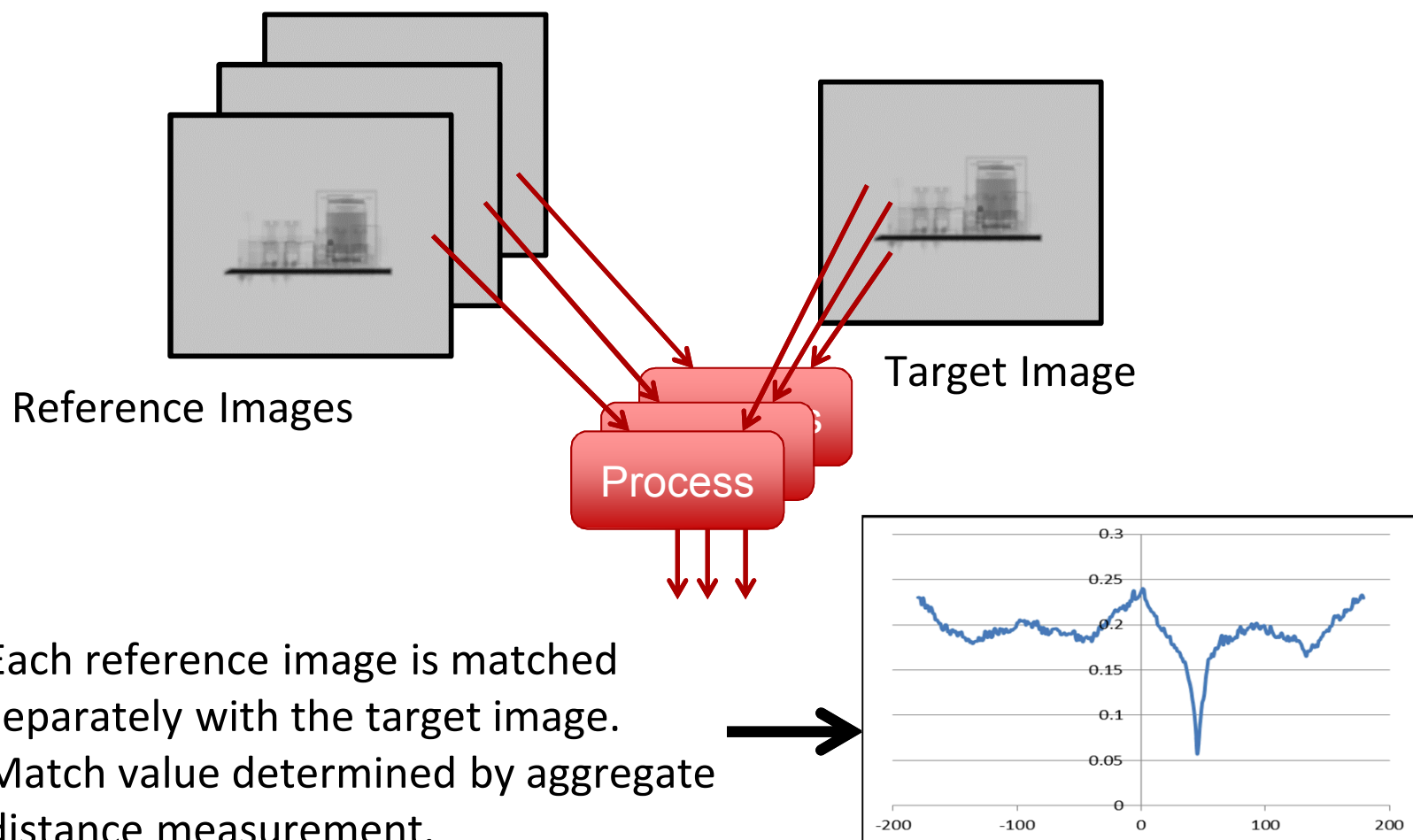
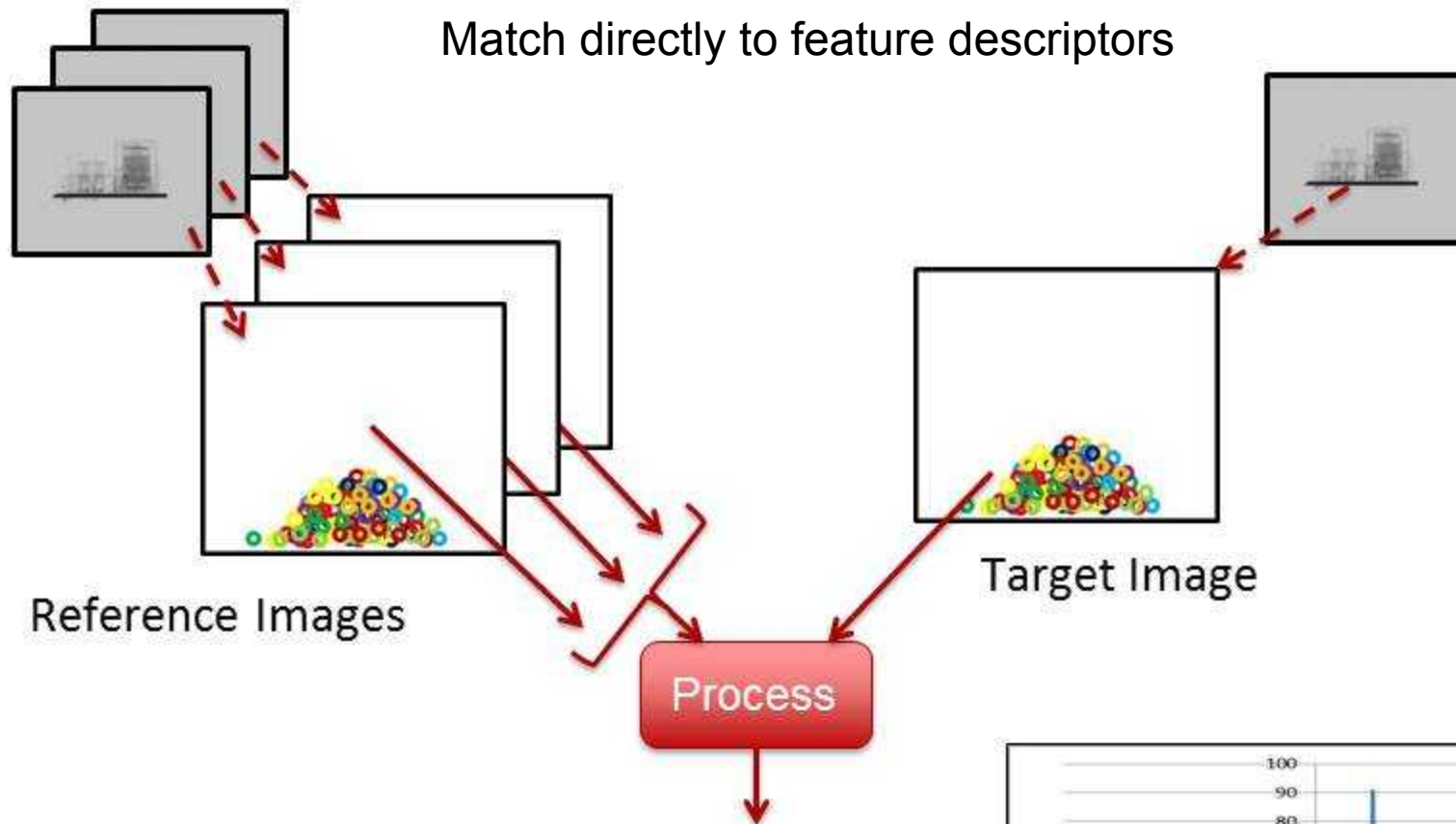


Image Matching -- Feature based matching

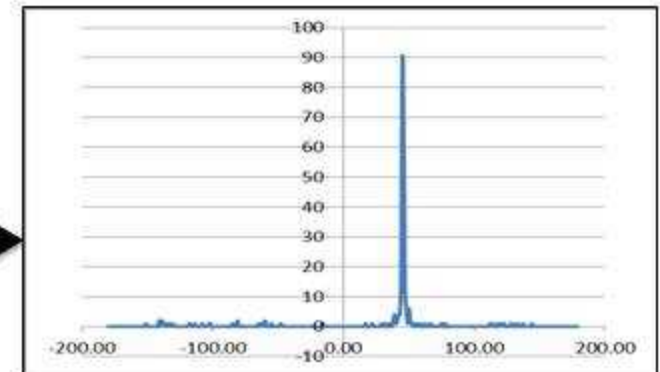
One-to-One Matching



Match directly to feature descriptors



All reference image features collectively matched with the target image. Match value determined by which ref image has the most features that match the target

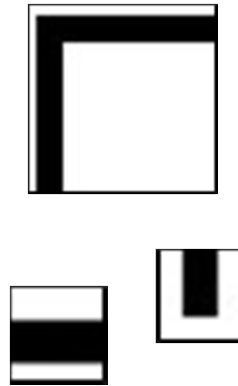
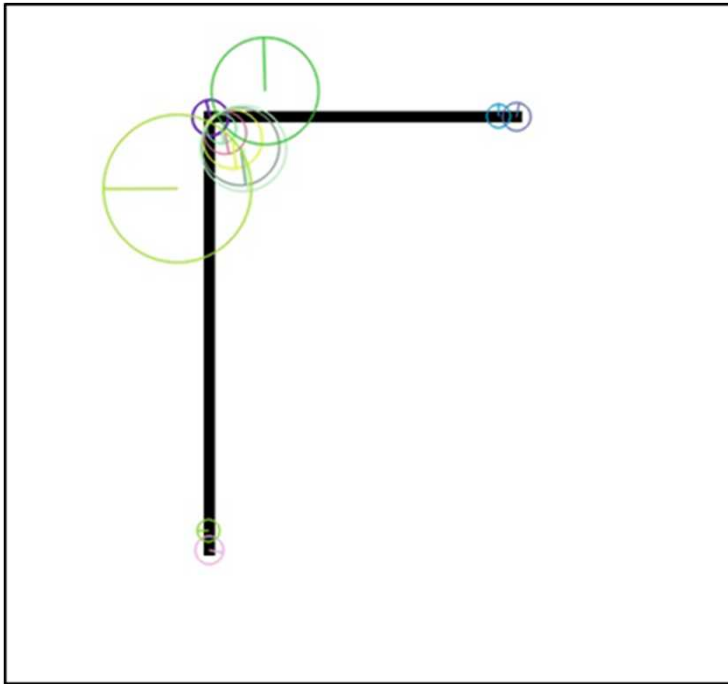


What does irreversibility mean?

1. The feature extraction algorithm is not directly (mathematically) invertible
2. If an image was created using features from representative images, the quality is insufficient for extracting any sensitive device characteristics.
3. The computation time required to recreate an interpretable image is insurmountable and nearly impossible on human time scale

Irreversibility

SURF (Speeded Up Robust Features)



Keypoints

– location, scale, orientation,...(7)

Keypoint descriptors

– array of numerical values (128)

Irreversibility

To recreate an image from feature data

(can't use original image patches, Daneshi and Guo)

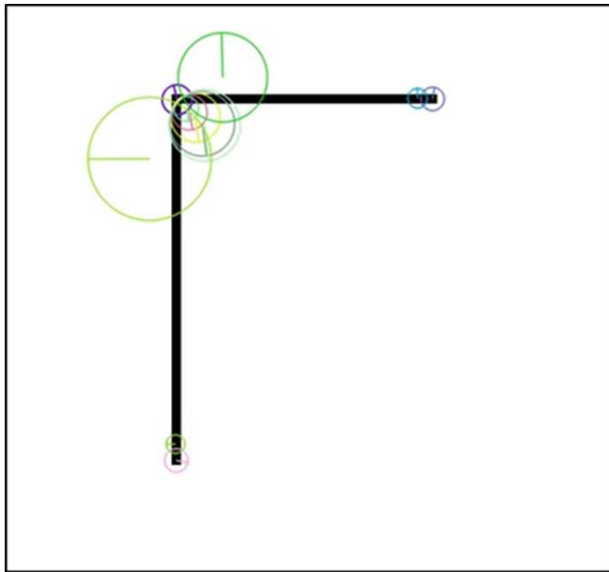
1. For each descriptor find a matching descriptor in a database of representative images and extract corresponding image patch
2. Place patch in the recreated image and scale accordingly to scale in descriptor
3. Repeat for all descriptors
4. Interpolate and combine patches to form image



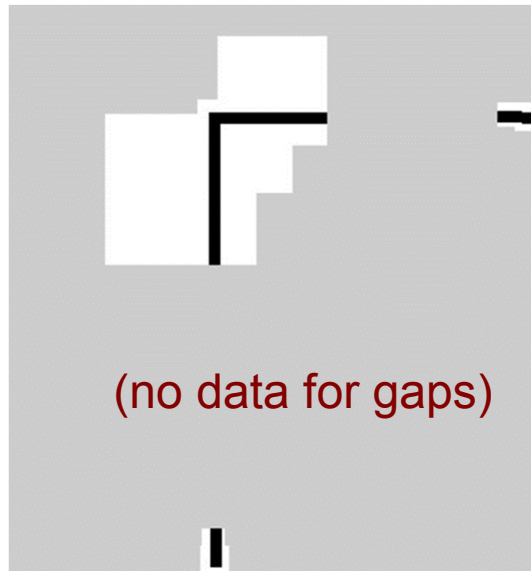
Irreversibility

If we found representative patches;

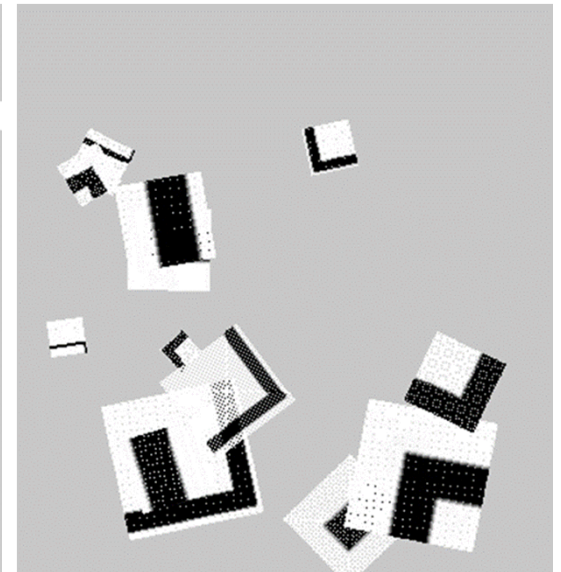
(Original)



With location, scale,
orientation



Without location, scale,
orientation



Probability of successfully reconstructing image

If each feature was centered on a given pixel within the to-be-created image, there are L pixel locations (rows x columns), and $L!$ combinations of pixel locations. Given M features, the number of possible arrangements N would be:

$$N = \frac{L!}{(L - M)!}$$

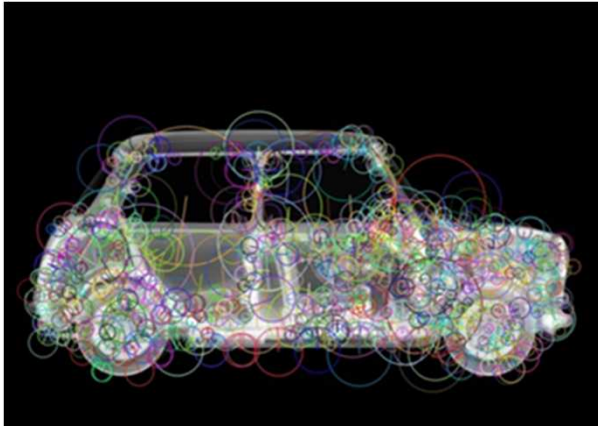
For an image of 100 pixels (10 by 10), with 20 features, N would be 1.30×10^{39} .

To calculate the expected time to a success, we use

$$T_{success} = \frac{pN}{2r}$$

where, p is the probability of success, N is the number of possible arrangements, and r is the rate the arrangements can be calculated. For the same 20 descriptors and 100 pixels, we will assume we want a 90% probability of success and the rate will be 5 MHz. It would require a time of 1.96×10^{30} minutes or 3.7×10^{24} years to test all possible arrangements.

Irreversibility



Example radiography image:

Car.jpg

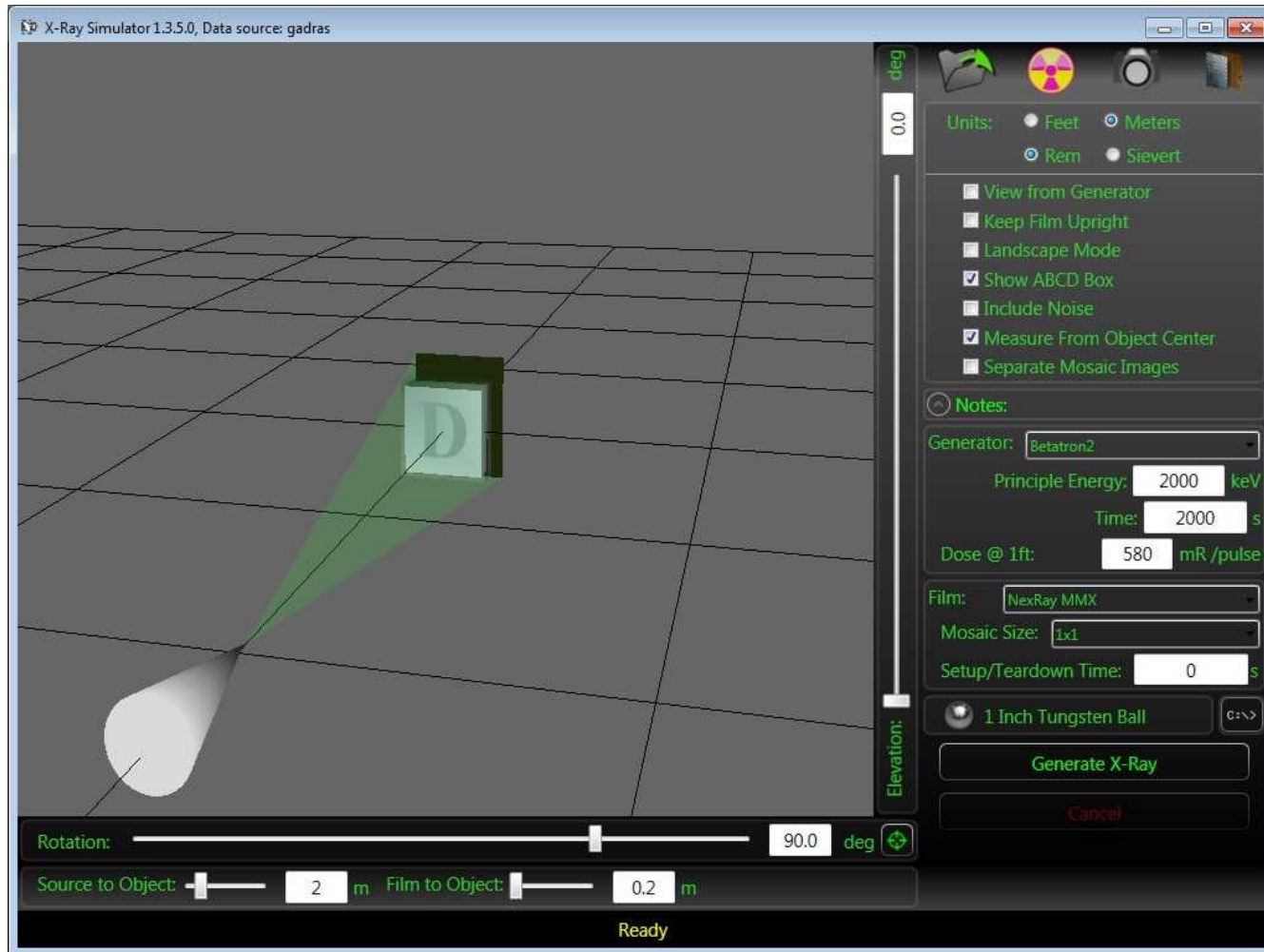
640 x 452 Pixels

1201 SURF Features

Unknown Orientation and Scale could be considered multipliers on the Position space when considering possible feature arrangements.

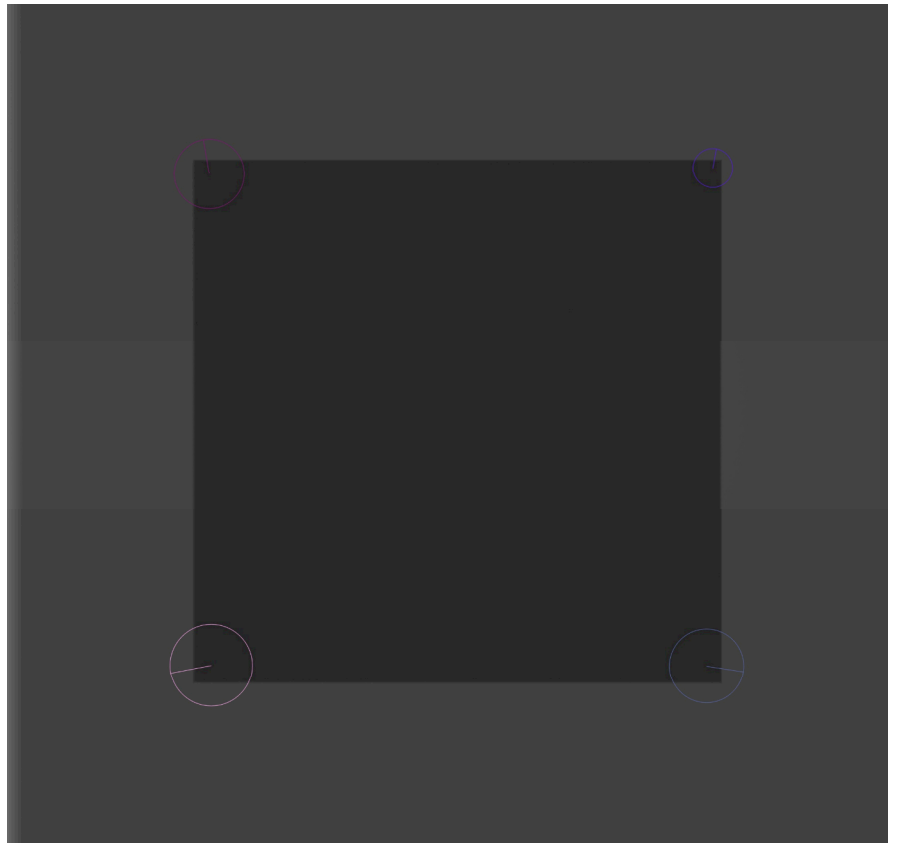
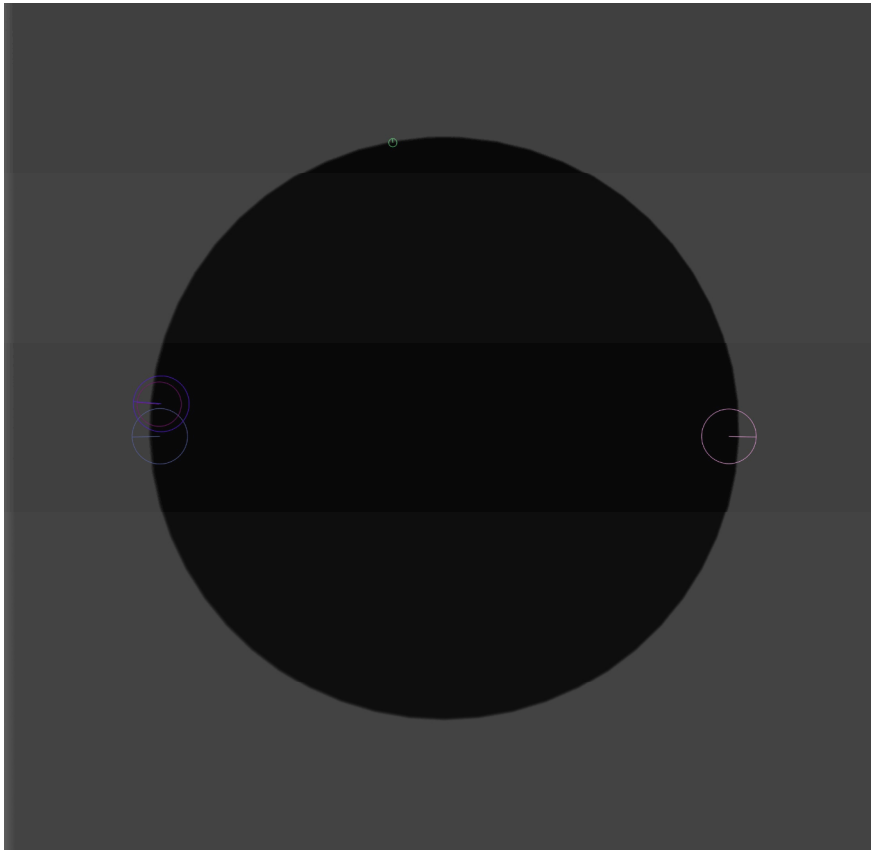
Challenge Problem

CAD model for X-ray simulation



Challenge Problem

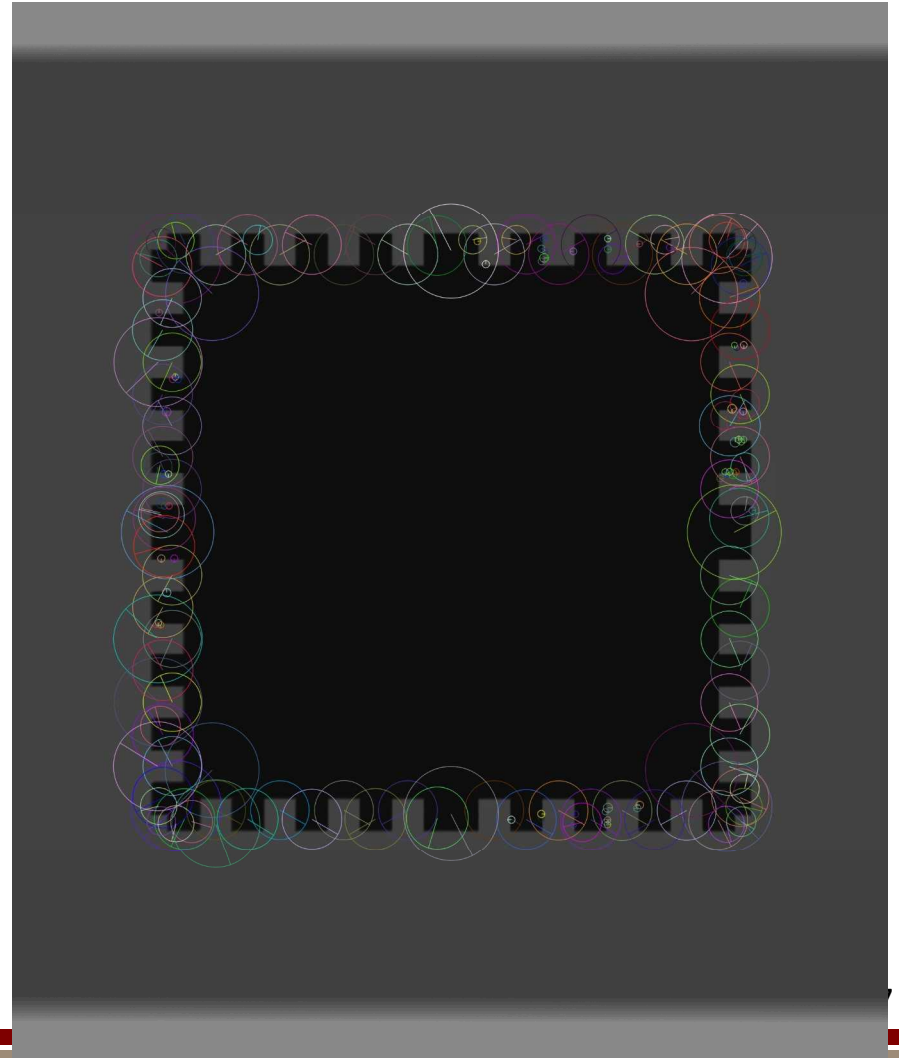
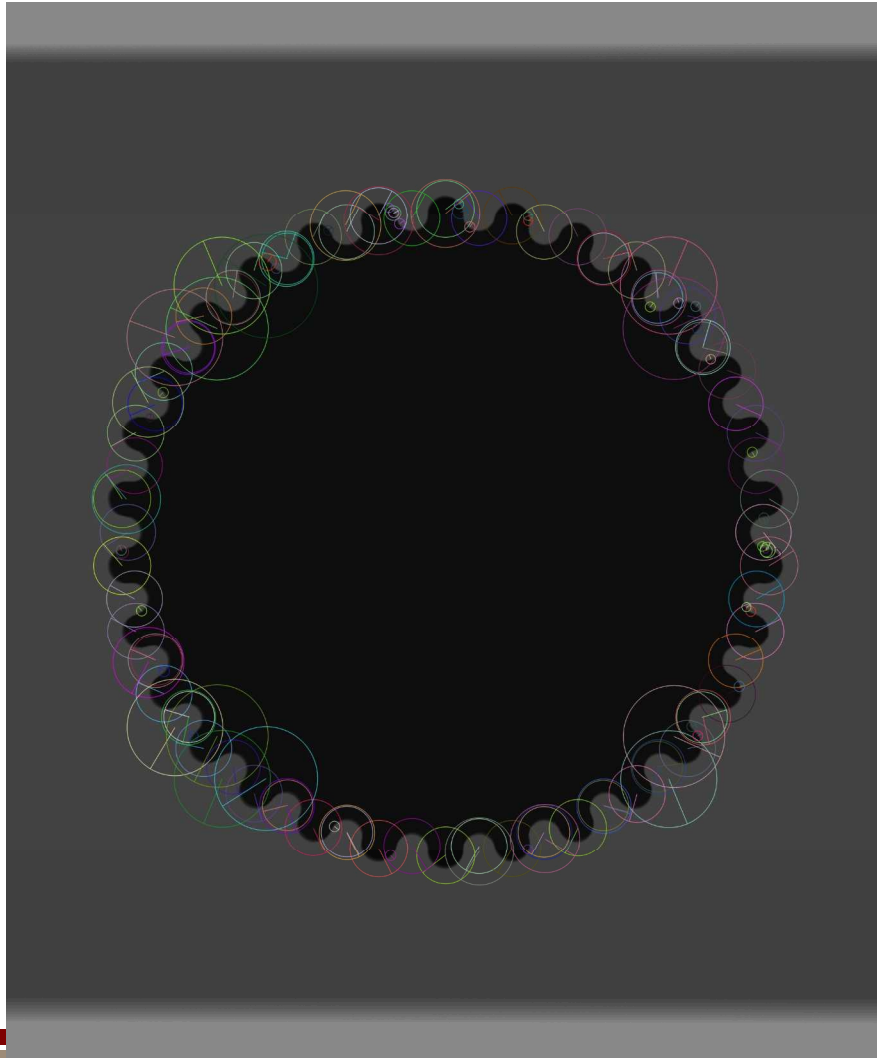
X-rays of original models with features



Too few features for algorithm

Challenge Problem

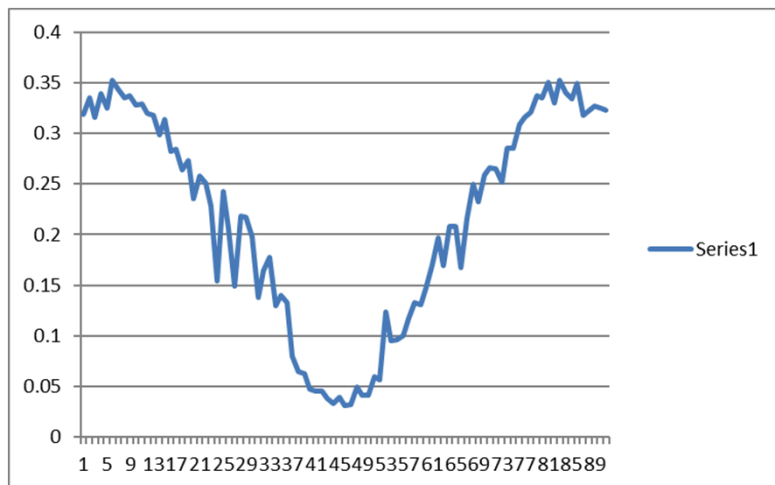
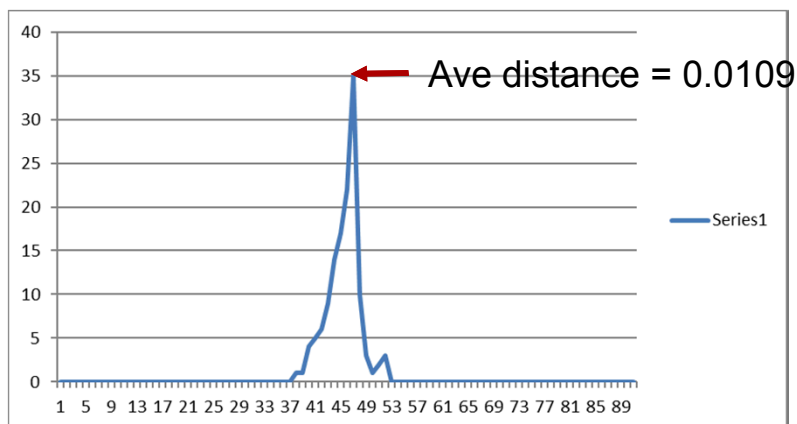
X-rays of modified models with features



Challenge Problem

Probe vs Reference set matching

Disk to Disk



Square to Disk

