Bubble detection

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Abstract

Keywords: Distributed sensing,network pruning

1 Comparison of bubble detectors and size distribution estimators

General

Bubble(circular objects) dtection algorithms can be divided into two approaches, geometry-based and appearance-based.

Geometry-based approaches detects parameterized circular objects in the image edge map.

Drawbacks: Sensitive to noise, high false positive rate.

Appearance-based appraches using sliding window combining with a classier like boosting based, Hog based and CNN classifier

Drawbacks: need large amount of training data.

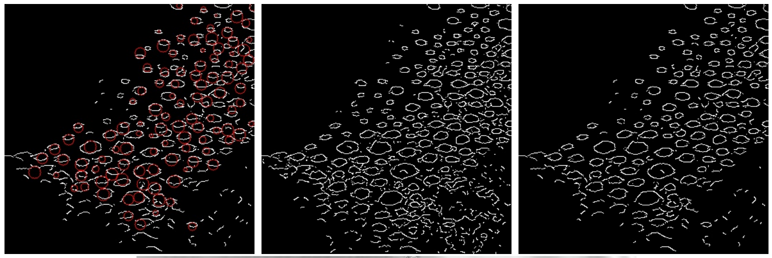
Estimation of bubble size

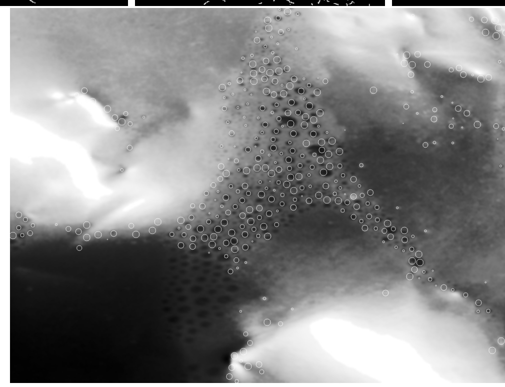
2 results of conventional techniques

The results of conventional image processin method are as follow:

As we can see from the results, bubbles with round extracted edge can be detected. However, the false positive rate and false negative rate are relatively high. The problems of hough circle detection can be listed as follows:

1. High false positive rate because hough circle detection tends to detect the arcs that can fits in a circular model.
2. Due to the different angle of view, the extracted edges of some bubble look more like ecllipse rather than a perfect circle. The circular bounding box can not perfectly mark out a bubble





3. The reflection of the surface will cause much false positive detection.

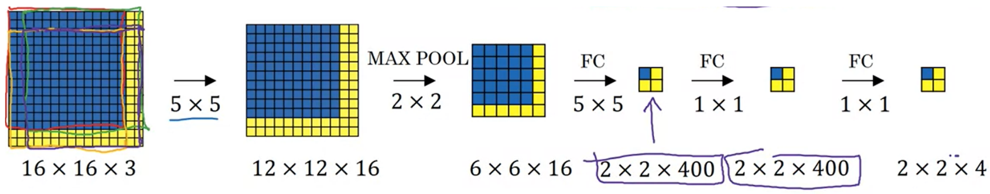
3 related work

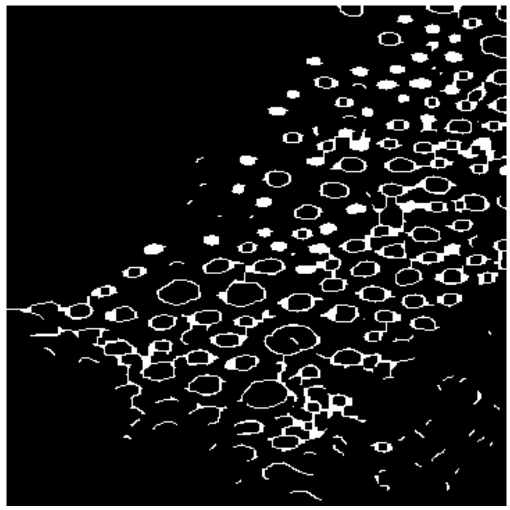
Jarmo Ilonen and etc has compared the performance of different bubble detection methods,which includes circular Hough transform (CHT) method, Concentric Circular Arrangements(CCA),boosting based method and CNN method.And the results shows that CNN method outerperform than other methods

They established a dataset, which contains 120 images(72 for training, 48 for testing, 20 images for each rotor speed).Each image is 1482 * 1482 pixel.During training, they extract each bubble using a 28 * 28 image patch and label it as positive examples. They also implement data augumentation like shifting and scaling. In this way,the training data contained 148,860 positive and 317,732 negative examples.

During bubble detection, they use sliding window of different scales as the input of CNN model to detect whether there is a bubble in the window. For lowest scale, the window size is 28 * 28. Since only square bounding boxes can be obtained in this way. The author integating the results of each window to form a detection image(detection probability map) under a certain scale. After that, they implement connected component analysis on the detection image. They first threshold the detection image into binary image. They reject the areas that do not meet the following requirments:

1. area is larger than ta
2. the proportion of the pixels in the convex hull that are one is larger than ts
3. the ratio of minor and major axis is larger than tm



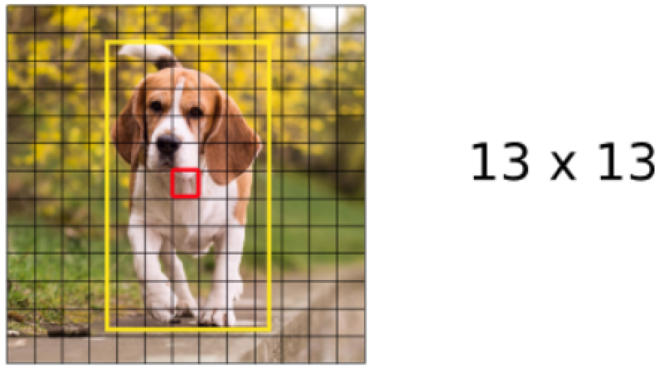


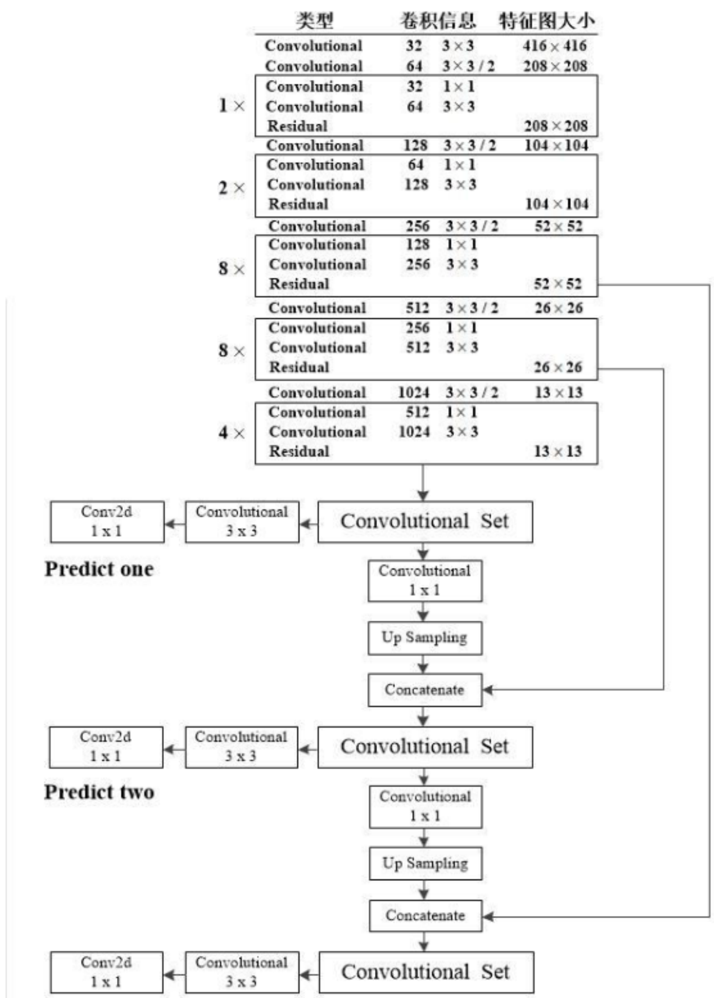
4 YOLO

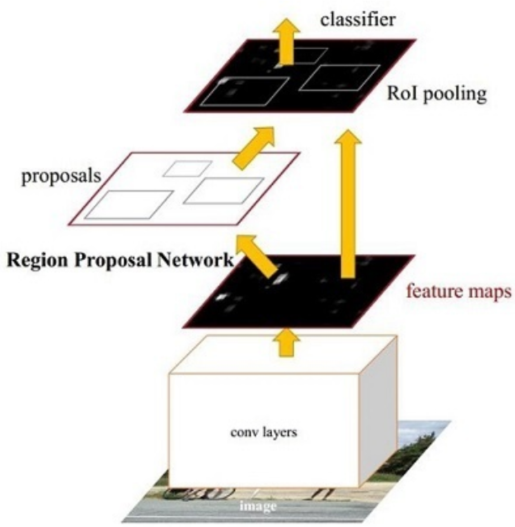
YOLO is a one stage object detection algorithm. The basic idea of yolo algorithm is also sliding windows. First, the image is split into multiple grids. As shown in the image, 13 by 13 grid is used. The final output of yolo is a 13 * 13 *(B*(5+C)) tensor. It means each grid corresponds to a pixel in final 13 * 13 feature map. The dimension of each pixel is (B*(5+C)). If we assume only one bounding box is detected in one grid and we only want to detect 3 classes, the final ouput can be written as $[P, bx, by, bw, bh, c1, c2, c3]$. During training phase, only the grid that the center of the GT box falls into are resbosible for detecting the object. In other words, the grid which contains the centroids of the GT bounding box is labeled as $[1, bx, by, bw, bh, c1, c2, c3]$

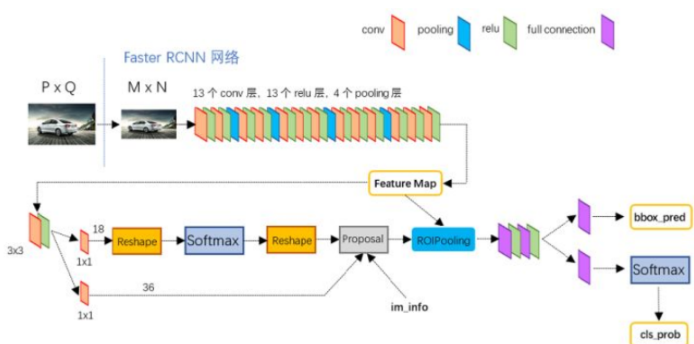
5 faster rcnn

The basic idea of faster rcnn is to using the RPN(region proposal network) to find the region of interest and use the region of interest as the input of CNN network to obtain the classification results. The basic structure of faster rcnn are shown in the follow figure. First, input the image to a convolutional layer to extract the features of the image. The features are used to obtained the bounding box proposal in the original image. Using the bounding box proposal and the features we can select the feature map inside the bounding box proposal and input them into the fully connected layer the detect which object is.


13 x 13


类型 卷积信息 特征图大小
Convolutional 32 3×3 416×416
Convolutional 64 3×3/2 208×208
1×
Convolutional 32 1×1
Convolutional 64 3×3
Residual 208×208
Convolutional 128 3×3/2 104×104
2×
Convolutional 64 1×1
Convolutional 128 3×3
Residual 104×104
Convolutional 256 3×3/2 52×52
8×
Convolutional 128 1×1
Convolutional 256 3×3
Residual 52×52
Convolutional 512 3×3/2 26×26
8×
Convolutional 256 1×1
Convolutional 512 3×3
Residual 26×26
Convolutional 1024 3×3/2 13×13
4×
Convolutional 512 1×1
Convolutional 1024 3×3
Residual 13×13
Conv2d 1 x 1
Convolutional 3 x 3
Convolutional Set
Predict one
Convolutional 1 x 1
Up Sampling
Concatenate
Conv2d 1 x 1
Convolutional 3 x 3
Convolutional Set
Predict two
Convolutional 1 x 1
Up Sampling
Concatenate
Conv2d 1 x 1
Convolutional 3 x 3
Convolutional Set


classifier
RoI pooling
proposals
Region Proposal Network
feature maps
conv layers
image


conv
pooling
relu
full connection
Faster RCNN 网络
P x Q
M x N
13 个 conv 层，13 个 relu 层，4 个 pooling 层
Feature Map
3x3
18
1x1
Reshape
Softmax
Reshape
Proposal
ROIPooling
36
1x1
im_info
bbox_pred
Softmax
cls_prob

6 System

Considering that we cannot obtain enough data and labelling the exact shape of each bubble is diffcult. I tend to construct the algorithm as follows:

1. Using sliding windows to generate small images and manually label them as bubble or no bubble.
2. Build a convolutional model that can output detection map of different scales using the data above
3. Extracts the bounding box of bubble based on the detection image.