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Measuring the Degree of Suitability of Edge Detection Operators Prior to an Application

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Introduction

- It is difficult to determine the suitability of edge detection operators on diverse set of images prior to an application.
- Edge Detection: Low-level feature extraction / Finding shape information about objects. An edge is a sharp discontinuity change across gray level boundaries.
- Purpose: Performs major role in many applications such as face recognition, medical imaging, remote sensing, robot vision, color image processing, industrial automation, etc.
- Subjective in nature as an appearance of an output image depends upon human perception.
- Use of regression models to determine the suitability of edge detection operators.

Problem Definition

- To design and develop a novel edge detector called Hybrid operator.
- To determine the degree of suitability of the edge detection operators prior to an application with the help of Regression Models.

Motivation

- It is a challenge to estimate the enhancement and segmentation qualities up to a standard mark prior to visual processing applications where objective nature is important rather than subjective nature of human perspective.
- Edge Detection Operators gives vision and visual information processing of images.
- Traditionally, edge detectors are compared by means of visible perception of edged output.
- Difficult to predict the appropriateness of edge detection output visually as Human perception varies from user to user.

Proposed Edge Detector

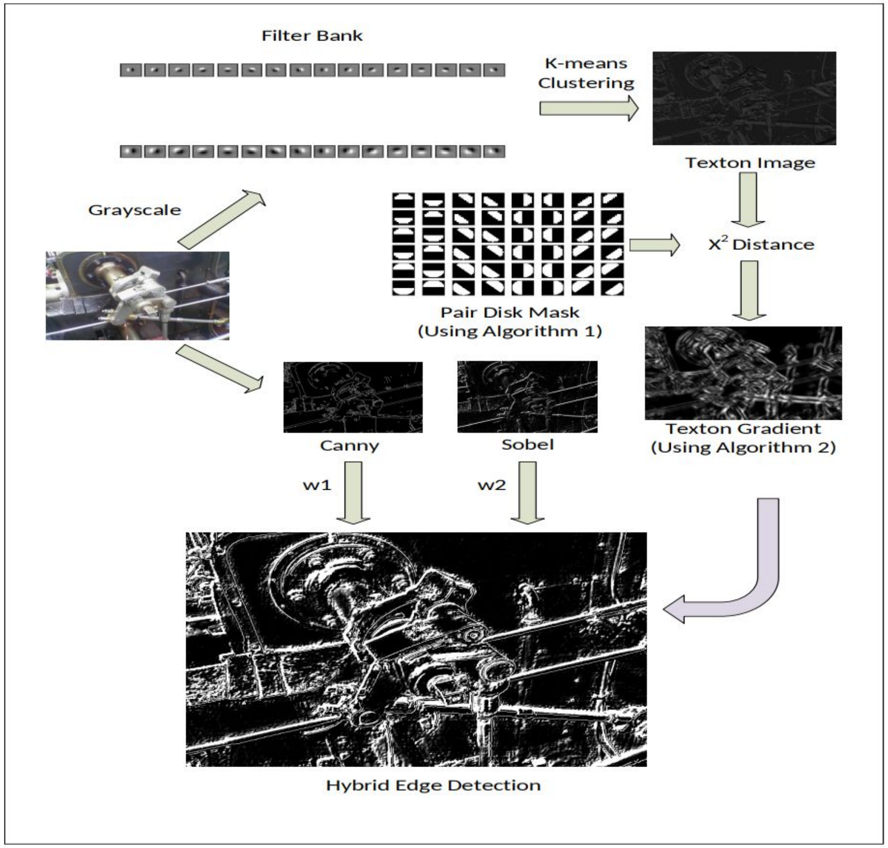


Fig. 1 : Design Process of Proposed Edge Detection Operator

Algorithms

Algorithm 1 PairDiskMask algorithm

Input : radius, orientation
Output : Pair Disk Mask

procedure PAIRDISKMASK($radius, hdmOrientation$)
  $pdMasks = [\,]$
  for <radii = 1:radius> **do**
    mask = create matrix with all zero's having size (radii∗2+1, radii∗2+1)
  end for
  for <i = 1:radii> **do**
    $x = i - radii^2$
    for <j = 1:$(radii * 2 + 1)$> **do**
      if $(x + (j - radii)^2 < radii^2)$ **then**
        $mask[i, j] = 1$
      end if
    end for
  end for
  $rotateAngle = 360.0/hdmOrientation$
  for <i = 1:hdmOrientation> **do**
    rotated=interpolate mask with $-i*$rotateAngle
    $rotated[rotated$>1]=1.0
    $rotated[rotated$<0]=0.0
    rotated_p=interpolate mask with $-i*$rotateAngle-180 ▷ Rotated Pair
    $rotated\_p[rotated\_p$>1]=1.0
    $rotated\_p[rotated\_p$<0]=0.0
    $pdMask \leftarrow rotated, rotated\_p$
  end for
  return $pdMask$
end procedure

Algorithm 2 GetGradient algorithm

Input : Image,PairDiskMask
Output : Gradient image

chi_sqr_dist=img∗0
for <i=1:num_bins> **do**
  temp = 1 where img is in bin i and 0 elsewhere
  g_i = convolve temp with left_mask
  h_i = convolve temp with right_mask
  update $chi\_sqr\_dist += 0.5 \times \sum_{i=1}^{num\_bins} \frac{(g_i - h_i)^2}{(g_i + h_i)}$
end for

Determining Suitability of Edge Detection Operators

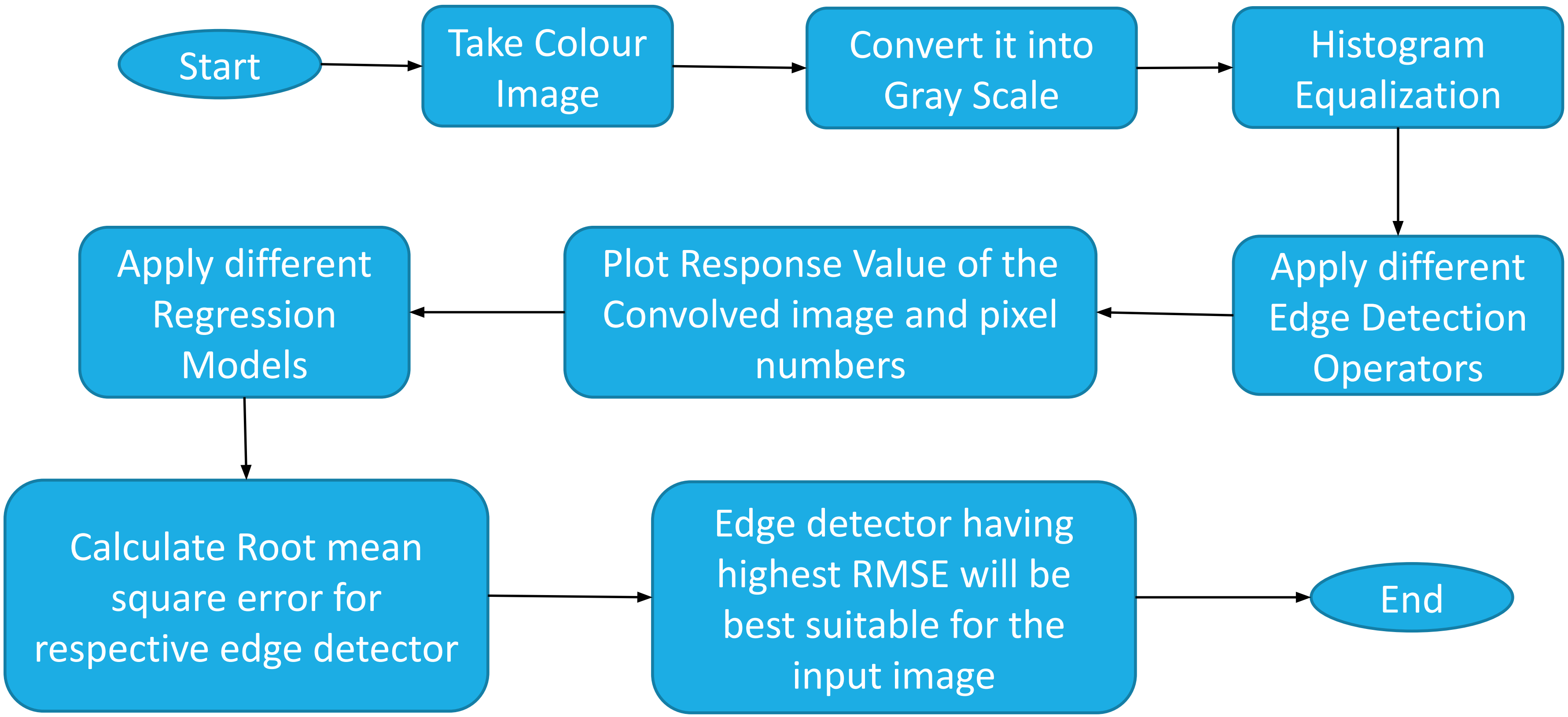


Fig. 2 : Flow diagram for determining the suitability of Edge Detection Operator

Contd…

Edge Detectors used

- Sobel, Prewitt, Roberts, Scharr, Laplacian, Canny and Hybrid (proposed).

Performance Metric

- RMSE is directly related to the strength of the discontinuity.
- More the RMSE for an edge detector, more sharp the discontinuity.

Models Used

- Linear Regression
- Support Vector Regression
- Multiple Regression

Database Description

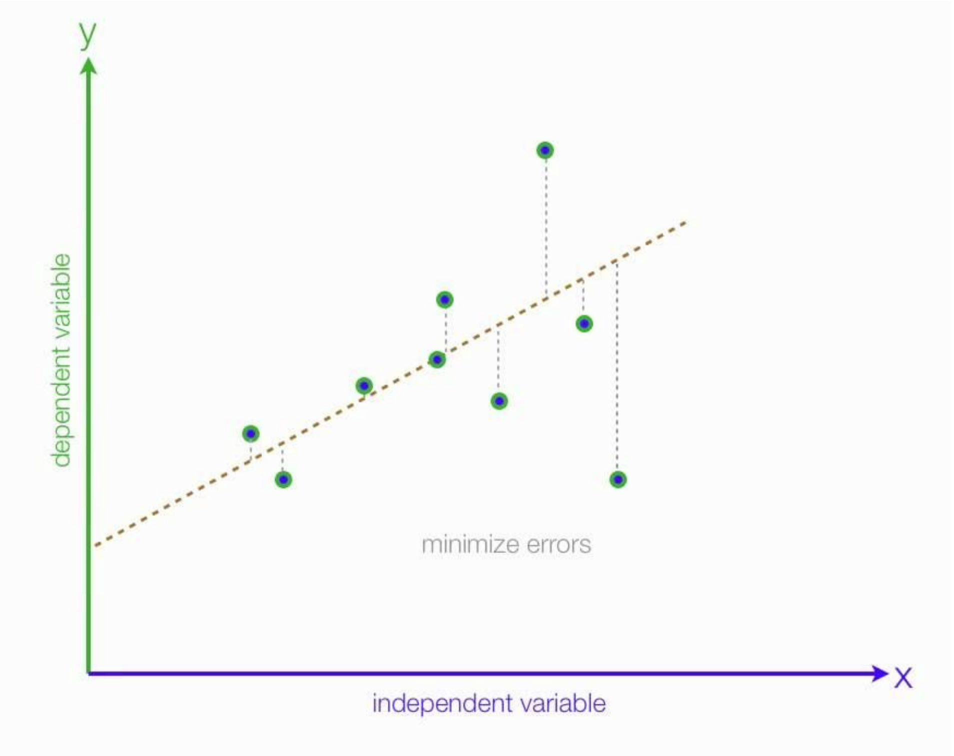
- The BSDS300, and the Multi-cue dataset are used for experiment.
- 200 images are selected randomly from BSDS300 for experiment.
- From Multicue, 10 scenes, each containing 20 images, are considered.

Linear Regression

In linear regression, one variable is considered independent (=predictor) variable (X) and the other the dependent (=outcome) variable Y.

- Y=mX+ c

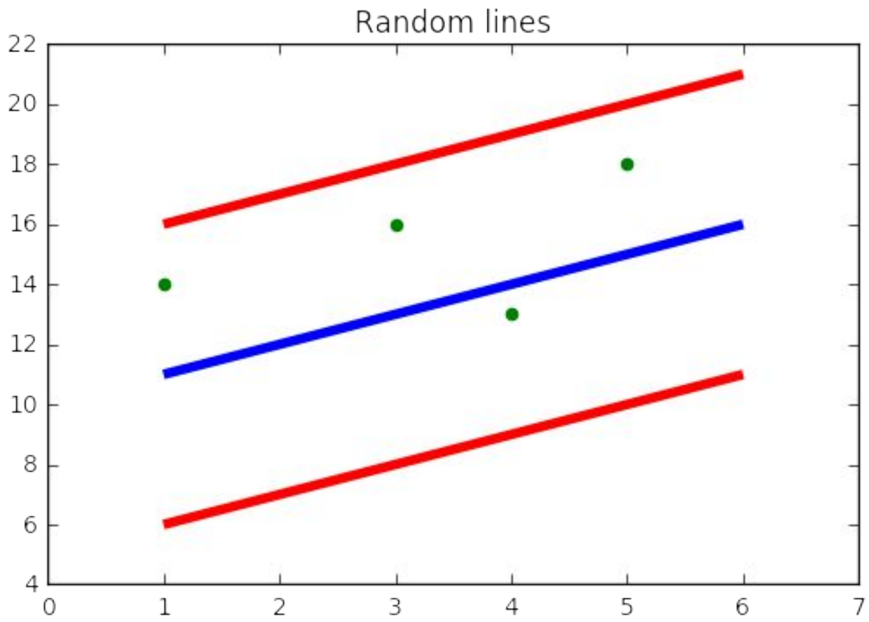
We have plotted the best-fit line using linear regression. Then we have calculated the root mean square error (RMSE) for each edge detector.



Support Vector Regression

SVR attempts to minimize the generalized error bound so as to achieve generalized performance.

We have used RBF (Radial Basis Function), which is a non-linear kernel. The kernel functions modify the data into a higher dimensional feature space so that we can perform the linear separation.



Blue line: Hyper Plane; Red Line: Boundary Line

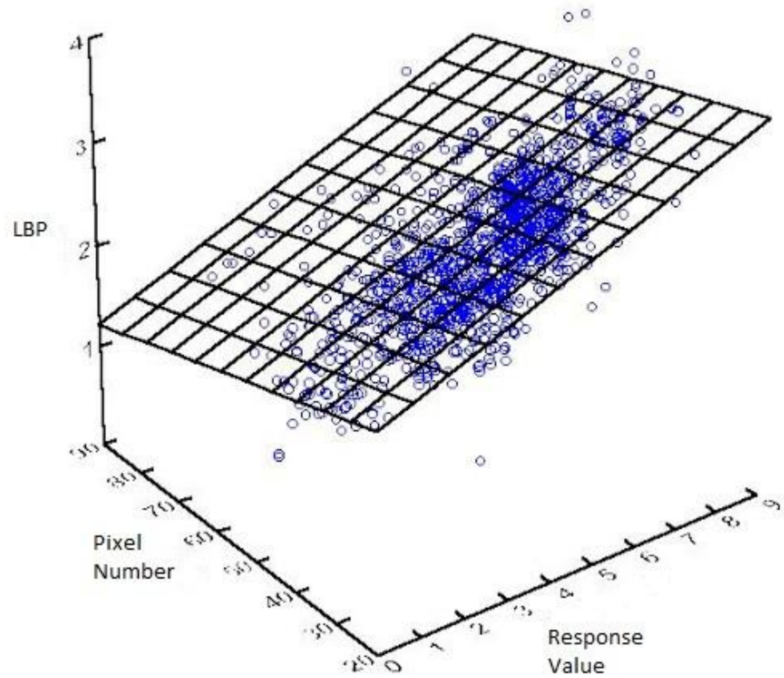
Multiple Regression

-Extended version of linear regression.

-It is useful when the variable's value depends on two or more variables value.

-Here, two independent variables and one dependent variable are taken.

-The second independent variable is taken as the local binary pattern (LBP) of the input image.



Results

TABLE I: RMSE on BSDS300 dataset

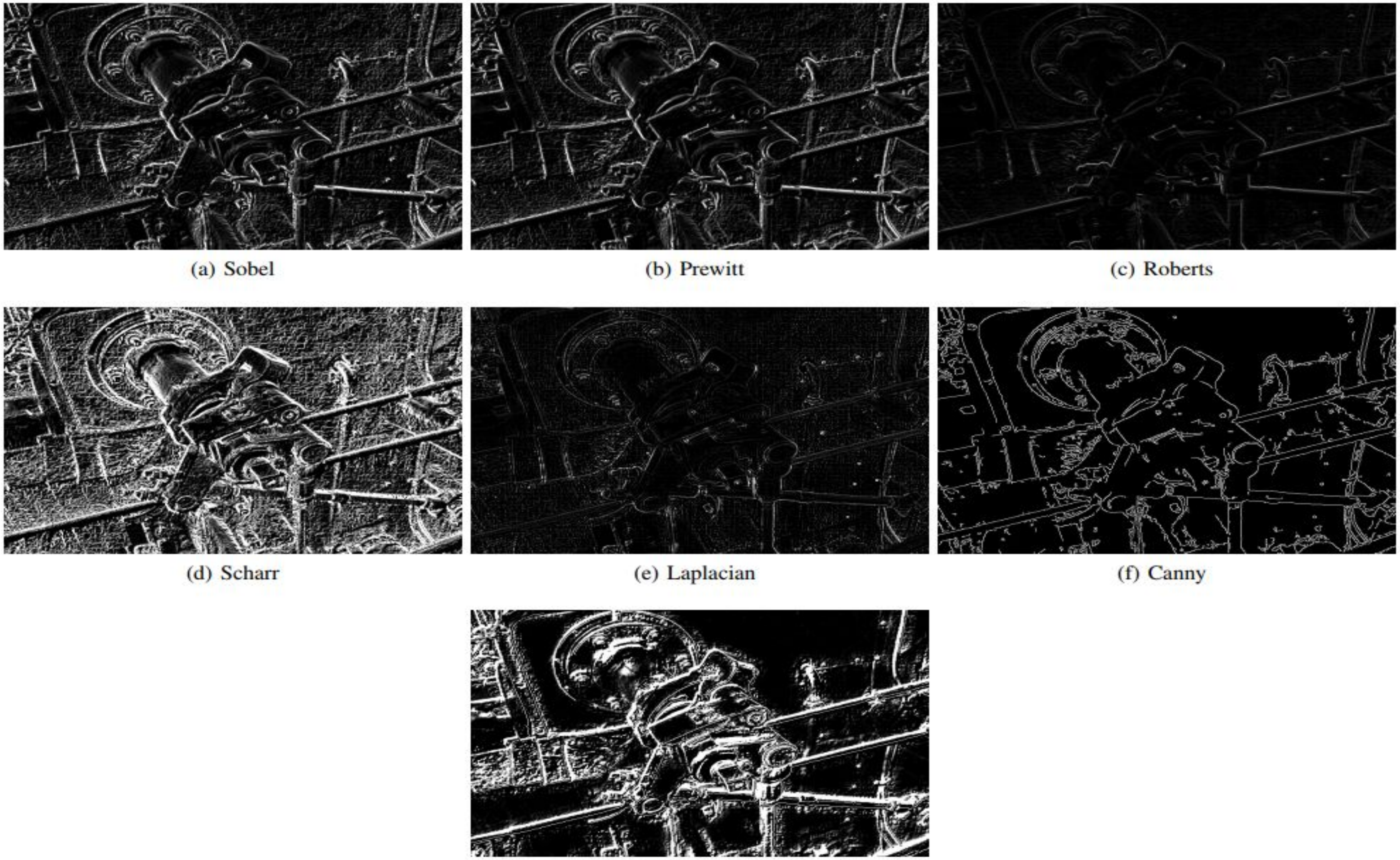
Edge Detector Operators	Linear Regression RMSE values					Support Vector Regression RMSE values					Multiple Regression RMSE values				
	Image-1	Image-2	Image-3	Image-4	Image-5	Image-1	Image-2	Image-3	Image-4	Image-5	Image-1	Image-2	Image-3	Image-4	Image-5
Sobel	67.16	79.24	89.44	78.56	87.45	72.48	83.65	91.23	80.61	91.94	60.58	74.70	101.33	76.33	86.98
Prewitt	59.66	69.56	79.58	67.77	78.61	64.27	72.96	81.50	69.30	83.31	50.49	64.47	85.23	63.08	74.95
Roberts	28.82	30.59	48.14	40.66	37.56	31.25	31.73	52.54	44.10	38.83	21.71	29.53	37.09	29.31	19.68
Scharr	102.34	111.46	107.01	107.84	113.31	106.02	115.24	123.47	109.93	120.40	120.44	133.85	164.56	136.98	145.68
Laplacian	67.12	81.20	91.79	86.74	92.42	73.22	93.66	107.89	100.81	109.48	40.24	70.11	84.85	80.27	86.32
Canny	92.72	117.33	120.65	119.45	121.71	98.99	135.42	141.98	138.94	144.47	43.39	79.30	86.95	83.18	90.14
Hybrid	1904.81	2420.90	3113.05	2294.91	2432.38	1982.51	2504.75	3282.15	2396.15	2535.72	847.61	1273.96	1783.85	1130.62	1397.27

Results

TABLE II: RMSE on Multi-cue dataset

Edge Detector Operators	Linear Regression Mean of RMSE values of 20 images					Support Vector Regression Mean of RMSE values of 20 images					Multiple Regression Mean of RMSE values of 20 images				
	Multi-cue Subject-1	Multi-cue Subject-2	Multi-cue Subject-3	Multi-cue Subject-4	Multi-cue Subject-5	Multi-cue Subject-1	Multi-cue Subject-2	Multi-cue Subject-3	Multi-cue Subject-4	Multi-cue Subject-5	Multi-cue Subject-1	Multi-cue Subject-2	Multi-cue Subject-3	Multi-cue Subject-4	Multi-cue Subject-5
Sobel	80.22	81.19	82.02	82.29	78.54	83.19	86.75	82.97	87.16	83.03	82.17	75.18	81.97	78.75	69.07
Prewitt	70.40	73.58	70.41	73.14	68.84	73.16	78.76	71.82	77.92	72.37	68.66	66.07	67.51	67.60	56.06
Roberts	39.27	46.71	32.70	33.23	33.88	41.29	50.45	33.59	34.83	35.79	47.46	37.48	27.05	27.83	26.05
Scharr	110.60	112.83	112.96	110.67	108.35	115.93	114.90	116.42	111.77	113.01	144.05	130.75	140.50	136.66	123.87
Laplacian	86.82	93.62	80.08	83.48	75.49	101.43	109.83	92.04	96.36	84.22	127.54	86.02	82.31	68.41	57.36
Canny	121.03	122.44	118.64	116.22	109.73	142.88	146.14	138.09	132.74	121.32	127.46	137.57	122.53	75.83	128.26
Hybrid	2451.29	2189.57	2374.61	2429.39	2503.49	2419.95	2213.87	2618.78	2632.04	2652.86	1444.44	1273.12	1317.54	1286.35	1114.34

Results



(a) Sobel (b) Prewitt (c) Roberts

(d) Scharr (e) Laplacian (f) Canny

(g) Hybrid

Fig. 3 : Pictorial comparison of Hybrid filter with Sobel, Prewitt, Roberts, Scharr, Laplacian, and Canny filters

Conclusions

- We have proposed a novel methodology to determine the appropriateness of edge detection operators using regression models.
- Hybrid operator outperforms other edge detection operators with extremely high RMSE value.
- Edge detector which gives higher RMSE value, would be considered as efficient edge operator.

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Thank You