

# BANGLA HANDWRITTEN NUMERAL CHARACTER RECOGNITION USING DIRECTIONAL PATTERN

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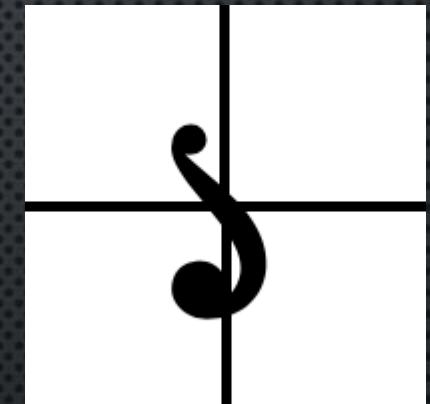
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# INTRODUCTION

- HANDWRITTEN CHARACTER RECOGNITION RECOGNIZES CHARACTERS FROM IMAGES OF HANDWRITING.
- MANY APPLICATIONS LIKE
  - AUTOMATED LICENSE PLATE IDENTIFICATION
  - TEACH MACHINES TO READ (LITERALLY)

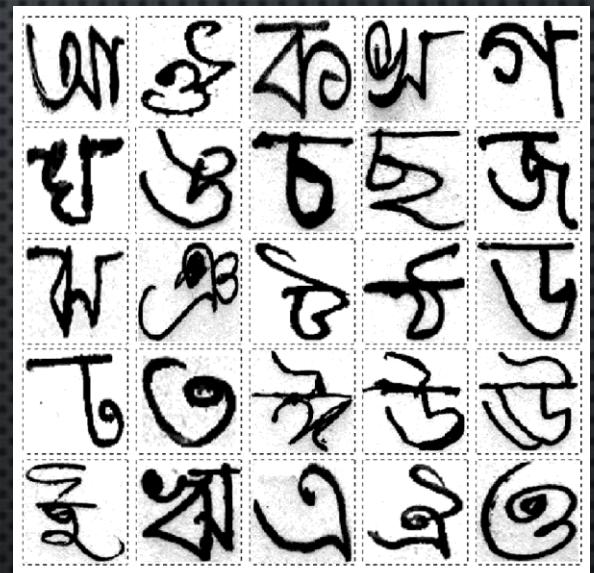
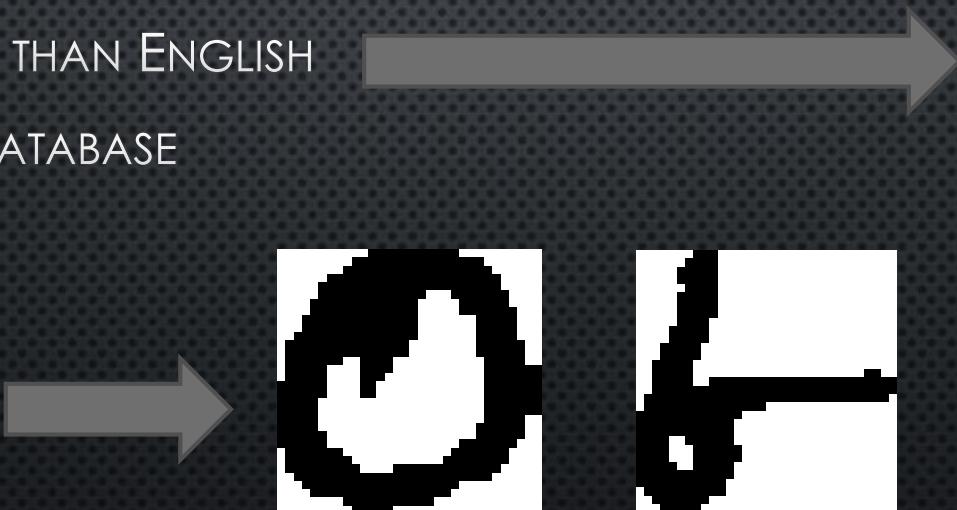
CLEAN UP YOUR MESS



CLEAN UP YOUR MESS

# BANGLA CHARACTER RECOGNITION

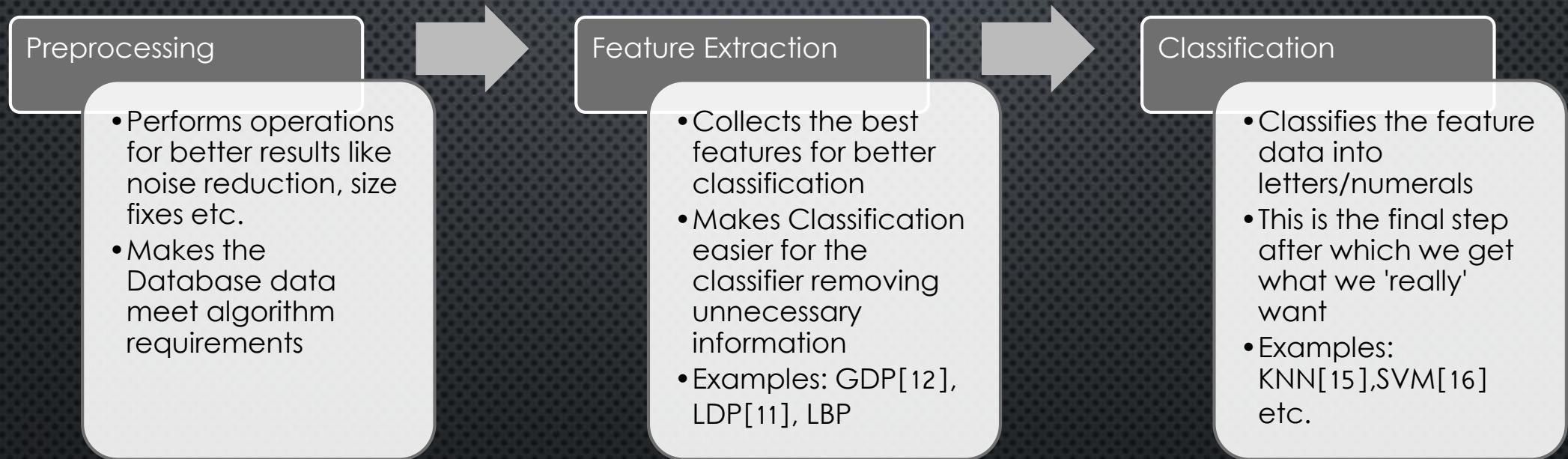
- A BIT MORE COMPLEX THAN ENGLISH
- PREVIOUS LACK OF DATABASE
- NOTABLE DATABASES
  - ISI [1]
  - CMATER [2]



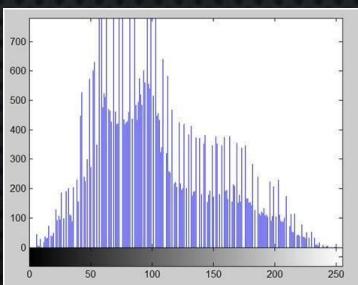
# BANGLA CHARACTER RECOGNITION DATABASES

- INDIAN STATISTICAL INSTITUTE
  - DIFFERENT DATABASES CONTAINING
    - ABOUT 56000 DIGIT IMAGES ( 23392 BANGLA )
    - BANGLA AND DEVNAGARI CHARACTER IMAGES
    - BANGLA VOWEL MODIFIERS AND COMPOUND CHARACTERS
  - [HTTPS://WWW.ISICAL.AC.IN/~UJJWAL/DOWNLOAD/DATABASE.HTML](https://www.isical.ac.in/~ujjwal/download/database.html)
- CENTER FOR MICROPROCESSOR APPLICATIONS FOR TRAINING EDUCATION AND RESEARCH
  - COMPUTER SCIENCE AND ENGINEERING DEPARTMENT, JADAVPUR UNIVERSITY, KOLKATA 700032, INDIA.
  - IMAGES OF ENGLISH, BANGLA AND HINDI CHARACTERS AND WORDS (6000 BANGLA DIGITS )
  - WEATHER, BUSINESS CARDS ETC. IMAGES ALSO
- [HTTP://WWW.CMATERJU.ORG/CMATERDB.HTM](http://www.cmaterju.org/cmaterdb.htm)

# STEPS OF HCR



0 2 2 6 8  
5 6 9 6 2



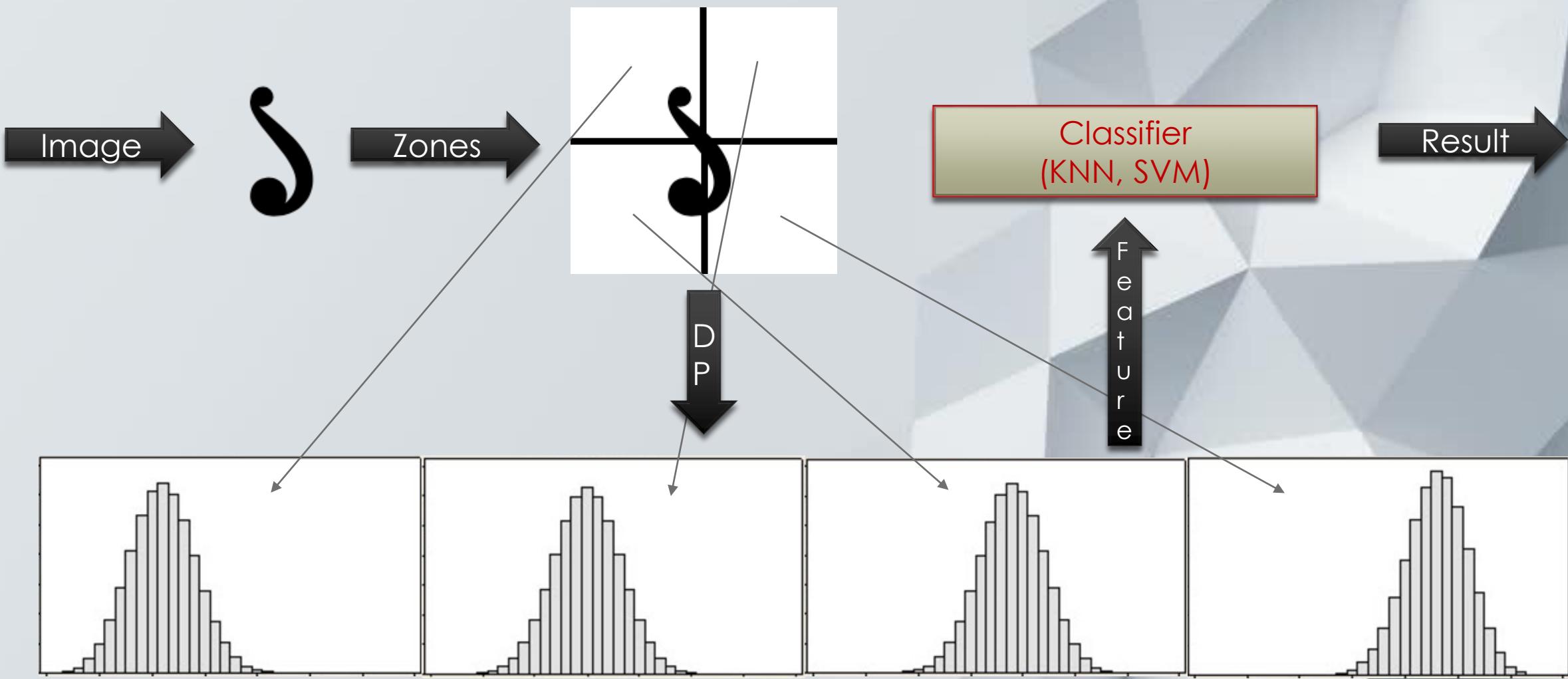
0 1 2 3 8  
5 6 9 8 9

# DIRECTIONAL PATTERN

- FOCUSES ON ITS SURROUNDINGS MORE
- WELL KNOWN FACIAL RECOGNITION ALGORITHM
- APPLIES MASKS/KERNELS TO IMAGES
- SOME NOTABLE PAPERS
- WE USED GDP AND LDP

# OUR PROPOSED METHOD

- WE DIVIDED THE IMAGE INTO BLOCKS
- WE USED LOCAL DIRECTIONAL PATTERN AND GRADIENT DIRECTIONAL PATTERN
- LDP APPLIES KIRSCH MASKS ON IMAGES
- GDP USES SOBEL KERNEL AND WORKS WITH GRADIENT
- WE GOT THREE RESULTS AND COMBINED THEM
  - GDP + KNN
  - LDP + KNN
  - LDP + SVM



# Method Flow Chart

# LOCAL DIRECTIONAL PATTERN

- I. APPLY MASKS TO GET 8 VALUES
- II. USING A VALUE OF K FIND THE BINARY PATTERN AS IN THIS CASE THE VALUE OF 3
- III. REPLACE THE CENTER VALUE WITH THE GAINED PATTERN
- IV. FORMULAE:
  - $LDP_k = \sum_{i=0}^{i=7} b_i(m_i - m_k)2^i$
  - $b_i(x) = \{1 \text{ when } x \geq 0; 0 \text{ when } x < 0\}$

35	123	79
16	10	201
101	56	99

Masks →

-738	-234	1094
-914	X	902
-746	-82	718

Kirsch Masks

K High →

0	0	1
0	X	1
0	0	1

$$\begin{aligned}
 M_0 &= \begin{bmatrix} -3 & -3 & +5 \\ -3 & 0 & +5 \\ -3 & -3 & +5 \end{bmatrix} & M_1 &= \begin{bmatrix} -3 & +5 & +5 \\ -3 & 0 & +5 \\ -3 & -3 & -3 \end{bmatrix} \\
 M_2 &= \begin{bmatrix} +5 & +5 & +5 \\ -3 & 0 & -3 \\ -3 & -3 & -3 \end{bmatrix} & M_3 &= \begin{bmatrix} +5 & +5 & -3 \\ +5 & 0 & -3 \\ -3 & -3 & -3 \end{bmatrix} \\
 M_4 &= \begin{bmatrix} +5 & -3 & -3 \\ +5 & 0 & -3 \\ +5 & -3 & -3 \end{bmatrix} & M_5 &= \begin{bmatrix} -3 & -3 & -3 \\ +5 & 0 & -3 \\ +5 & +5 & -3 \end{bmatrix} \\
 M_6 &= \begin{bmatrix} -3 & -3 & -3 \\ -3 & 0 & -3 \\ +5 & +5 & +5 \end{bmatrix} & M_7 &= \begin{bmatrix} -3 & -3 & -3 \\ -3 & 0 & +5 \\ -3 & +5 & +5 \end{bmatrix}
 \end{aligned}$$

# GRADIENT DIRECTIONAL PATTERN

- PERFORM CONVOLUTION WITH TWO KERNELS TO GET TWO VALUES FOR EACH PIXEL.
- FIND THE GRADIENT (Y/X) PIXEL-WISE
- USING A THRESHOLD T ASSIGN BINARY VALUES TO EACH PIXEL
- TAKING  $3 \times 3$  MATRICES AT A TIME FIND THE CENTER VALUE LIKE GDP.
- FORMULAE:
  - $GDP(x_c, y_c) = \sum_{p=0}^{p-1} w(GA_p - GA_c)2^p$
  - $GA(x, y) = \tan^{-1}(G_y/G_x)$
  - $w(GA_p - GA_c)2^p = \{1 \text{ when } GA_c - t \leq GA_p \leq GA_c + t; 0\}$

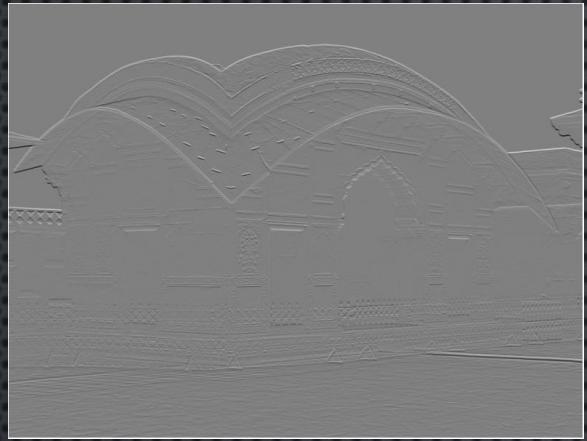
X – Direction Kernel

-1	0	1
-2	0	2
-1	0	1

Y – Direction Kernel

-1	-2	-1
0	0	0
1	2	1

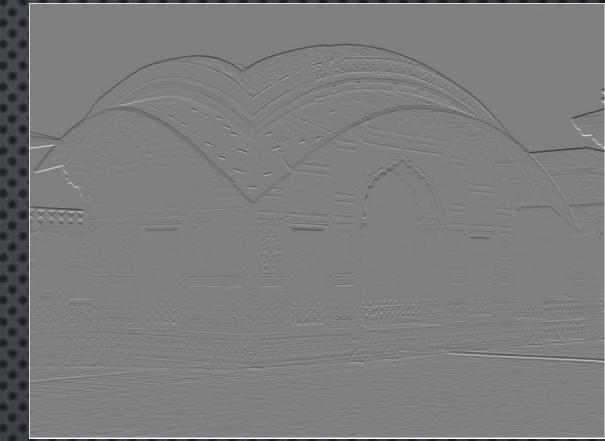
$$\begin{aligned} &= \left( \begin{bmatrix} +1 & 0 & -1 \\ +2 & 0 & -2 \\ +1 & 0 & -1 \end{bmatrix} * \begin{bmatrix} 35 & 123 & 79 \\ 16 & 10 & 201 \\ 101 & 56 & 99 \end{bmatrix} \right) \\ &= -35 + 0 + 79 - 32 + 0 + 402 - 101 + 0 + 99 \\ &= 412 \end{aligned}$$



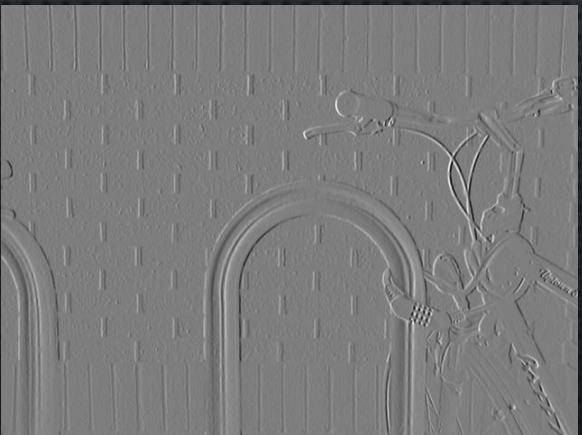
North Mask (2)



Original Image



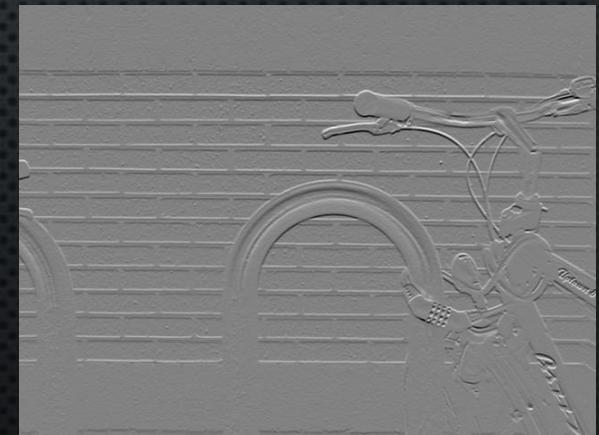
South Mask (6)



X grad



Y grad



# EXPERIMENTAL ANALYSIS

- WE FORMED DIFFERENT BLOCKS OF THE WHOLE IMAGE AND CREATED SOME ZONE SETS.
- WE APPLIED OUR PROPOSED DIRECTIONAL PATTERNS ON EACH BLOCK SEPARATELY.
- WE FORMED A HISTOGRAM COUNT OF LENGTH 256 (HIGHEST VALUE) FOR EACH BLOCK AND USED ALL THE HISTOGRAMS AS A FEATURE FOR A SINGLE IMAGE AND THEN PERFORMED CLASSIFICATION.
- WE FINE TUNED THE FOLLOWING VALUES THROUGH REPEATED EXPERIMENTS
  - VALUE OF K FOR LDP
  - VALUE OF THRESHOLD T FOR GDP
  - APPROPRIATE BLOCK SIZE OR ZONE SET
  - VALUE OF K FOR KNN FOR EACH PATTERN

# EXPERIMENTAL ANALYSIS (CONTD.)

## Zone-Wise Accuracy

Zones	LDP	Zones	GDP
$2 \times 2$	88.75	$5 \times 5$	93.43
$4 \times 4$	93.42	$6 \times 6$	94.05
$8 \times 8$	93.28	$10 \times 10$	93.88

## Digit-wise classification rate (%)

Digits	LDP	GDP	LDP+GDP
0	98.67	99.00	98.83
1	94.83	94.50	96.00
2	97.50	97.67	98.17
3	92.67	93.50	95.50
4	98.17	97.00	97.83
5	88.33	92.00	94.00
6	86.50	87.17	90.33
7	98.00	97.83	98.33
8	99.00	98.83	99.00
9	88.17	83.00	88.17

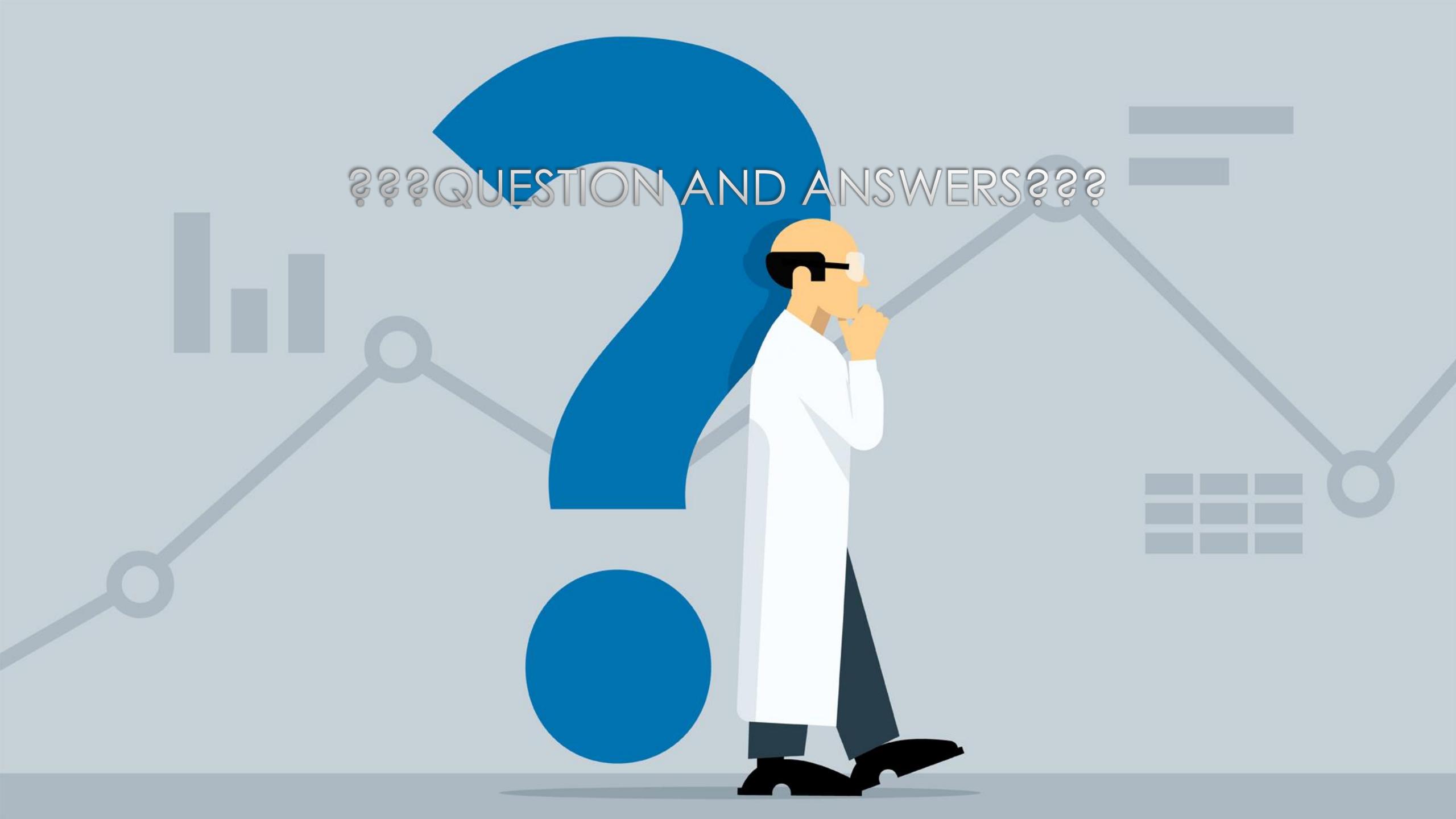
## Comparison of different approaches

Recognition Methods	Accuracy
<b>KNN(GDP+LDP) + SVM(LDP)</b>	<b>95.62</b>
<b>KNN(GDP+LDP)</b>	<b>94.43</b>
<b>KNN(GDP)</b>	<b>94.05</b>
<b>KNN(LDP)</b>	<b>93.42</b>
<b>SVM(LDP)</b>	<b>92.85</b>
<b>KNN(Basic LBP)</b>	<b>92.23</b>
<b>SVM(GDP)</b>	<b>90.47</b>

# CONCLUSION AND FUTURE WORK

- EVEN WITHOUT PREPROCESSING GIVES HIGH ACCURACY
- CAN WORK WITH NOISIER DATASETS IF REQUIRED
- NEURAL NETWORK ALGORITHMS USUALLY GIVE BETTER RECOGNITION
- SCOPE FOR FUTURE RESEARCH
  - APPLYING BETTER ALGORITHMS LIKE CNN
  - APPLY OUR METHODS FOR BANGLA LETTERS, COMPOUND CHARACTERS, VOWEL MODIFIERS ETC.

??QUESTION AND ANSWERS??



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Thank  
You!