Handwritten Character Recognition

PROJECT REPORT

Artificial Intelligence(CSE3013)

Submitted To:-

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Problem Statement:-

Handwritten character recognition is a field of research in artificial intelligence, computer vision, and pattern recognition. A computer performing handwriting recognition is said to be able to acquire and detect characters in paper documents, pictures, touch-screen devices and other sources and convert them into machine-encoded form. Its application is found in optical character recognition and more advanced intelligent character recognition systems. We will be predicting the handwritten character by using Artificial intelligence approach.

Introduction

Image classification is one of the core problems of computer vision, image classification refers to the task of extracting information classes from a multiband raster image. One of the important applications of image classification is the optical character recognition (OCR). OCR is the electronic conversion of scanned images of handwritten text into machine encoded text. In Optical character recognition, an algorithm will be trained on a dataset of known character in order to learn how to classify characters included in test set accurately. A variety of algorithm has been developed for classifying letter and digits from last decades. In the field of optical character recognition there are three methods: template matching, feature extraction and classification, third one is the deep learning method.

(i) Motivation :-

Handwriting is one of the easiest and natural ways of communication between humans and computers. Signature verification has been an active research topic for several decades in the image processing and signature verification remains a challenging issue. It provides a way of identifying the writer of a piece of handwriting in order to verify the claimed identity in security and related applications. It requires the writer to write the same fixed text. In the sense, signature verification may also be called text dependent writer verification. In practice, the requirement, the requirement and the use of fixed text makes writer verification it relatively less useful as it's not useful in many application. For example the identification of the writer of archived handwritten documents, crime suspect, identification in forensic science, etc. In these application, the writer of a piece of handwriting is often identified by professional handwriting examiners. Although human intervention in the text independent writer identification has been effective, it is costly and prone to fatigue. This task is much more difficult and useful than signature verification. So we got the motivation to do this challenging project.

(ii) Significance :-

Character recognition (CR) is a procedure of machine simulation of human interpretation. It is a skill of acquiring, cleaning, recognizing and segmenting characters from an image. This procedure translates the image beneath consideration into a revisable design. Procedure of handwritten characters usually is favourable in numerous fields like signature and courtesy amount of bank cheque, information filled in tax forms, reading zip codes on envelopes etc. Numerous techniques for extraction of features of characters are helpful technique as it focuses on local characteristics of the characters. Thus it assists to gain exhaustive knowledge of alphabets therefore enhancing the procedure of recognizing characters. Task of character recognition (CR) is serious in creating a paperless situation by converting older handwritten articles into electronic collection. HCR gives extremely to the growth of automation procedure and thus improving the communication among human and machine. It isn't easy job to build a software program to achieve 100% precision for identification of handwritten English alphabets just as still though humans too create errors to identify alphabets correctly. Handwritten characters differ depending upon the writer (similar or diverse). So there is forever a necessity to enlarge a proficient handwritten recognition system. HCR has some potential applications which generate the requirement for developing such schemes in an advanced manner. It facilitates to decrease the space need to save the data and creates it flexible to utilize.

(iii) Scope and Applications:-

1.)To recognize the handwritten character and providing the most accurate results.
2.) Identifying different handwriting styles and then predicting the result.
3.) To build a system that will recognize characters in a way that reduces its manpower cost and also reduce the time to translate them.
4.) To make it artificially intelligent to easily recognize the characters and use it for further purposes.

Literature Survey

1.) K. Gaurav, Bhatia P. K. ,, this paper deals with the various pre-processing techniques involved in the character recognition with different kind of images ranges from a simple handwritten form based documents and documents containing colored and complex background and varied intensities. In this, different preprocessing techniques like

skew detection and correction, image enhancement techniques of contrast stretching, binarization, noise removal techniques, normalization and segmentation, morphological processing techniques are discussed. It was concluded that using a single technique for preprocessing, we can't completely process the image. However, even after applying all the said techniques might not possible to achieve the full accuracy in a preprocessing system.

(K. Gaurav and Bhatia P. K., "Analytical Review of Preprocessing Techniques for Offline Handwritten Character Recognition", 2nd International Conference on Emerging Trends in Engineering & Management, ICETEM, 2013)

2.) Jia Xiadong, Gong wedong, Yuan Jie , CNN is used by many researchers for character recognition task but they concluded two main problem which they face while using CNN.

(i) The first problem in CNN is the manual training of data is very time consuming and it is labor intensive.

(ii)Second problem is the design and parameter problem all depend on experiences.

(iii) To address these problem stated above they use density based clustering algorithm which is used as remedy for the first problem that means it is effective in data labeling.

In this paper the handwritten Yi character recognition is divided into two parts. In the first part they describe how to construct the Yi characters database which uses improved density based clustering algorithm and in the second part they explain CNN architecture. In the construction of dataset they scan the Yi character documents then they binarize and normalize them and finally an image slice is used as the input in the clustering algorithm.

(Jia xiaodong, gong wednog, yuan jie, "Handwritten Yi Character Recognition with Density Based Clustering Algorithm and Convolutional Neural Network", 2017 IEEE International

Conference on Computational Science and Engineering (CSE) and IEEE International Conference Embedded and Ubiquitous Computing (EUC).)

3.) Sandhya Arora in [12], used four feature extraction techniques namely, intersection, shadow feature, chain code histogram and straight line fitting features. Shadow features are computed globally for character image while intersection features, chain code histogram features and line fitting features are computed by dividing the character image into different segments.

(Sandhya Arora, "Combining Multiple Feature Extraction Techniques for Handwritten Devnagari Character Recognition", IEEE Region 10 Colloquium and the Third ICIIS, Kharagpur, INDIA, December 2008)

4.) Hassiba Nemmour et al had taken care of handwritten Arabic word recognition. Two approaches for word recognition such as analytic and holistic approaches are explained. Ridgelet transform is used for feature extraction. Advantage of using ridgelet is to highlight the line singularities in the handwritten words. SVM is used as the classifier.

(Hassiba Nemmour and Youcef Chibani,"Handwritten Arabic Word Recognition based on Ridgelet Transform and support Vector Machines", IEEE, pp: 357-361, 2011)

5.) Anita Pal et al focus on the recognition of English handwritten character using neural network. Input character is acquired by scanning. Skeletonization and normalization are used as preprocessing steps. The features are extracted from the handwritten character by using boundary tracing along with Fourier Descriptor. Multilayer Perceptron Network is used for the classification of extracted feature.

(Anita Pal and Davashankar Singh,"Handwritten English Character Recognition Using Neural Network", International Journal of Computer Science and Communication, pp: 141-144, 2011.)

6.)Karanbir Kaur et al had taken care of English handwritten character recognition. Introduce image cropping, gray the image and binarization as preprocessing steps. 40-point feature

extraction is introduced for extracting the features of the handwritten alphabets. ANN is used for classification.

(Karanbir Kaur and Naresh kumar Garg,"Use of 40-point Feature Extraction for Recognition of Handwritten Numerals and English Characters", IJCTA, pp: 1409-1414, 2014.)

7.) Mohammed Z. Khedher, Gheith A. Abandah, and Ahmed M. Al Khawaldeh et al, this paper describes that Recognition of characters greatly depends upon the features used. Several features of the handwritten Arabic characters are selected and discussed. An off-line recognition system based on the selected features was built. The system was

trained and tested with realistic samples of handwritten Arabic characters. Evaluation of the importance and accuracy of the selected features is made. The recognition based on the selected features give average accuracies of 88% and 70% for the numbers and letters, respectively. Further improvements are achieved by using feature weights based on insight gained from the accuracies of individual features.

(Mohammed Z. Khedher, Gheith A. Abandah, and Ahmed M. Al- Khawaldeh, "Optimizing Feature Selection for Recognizing Handwritten Arabic Characters", proceedings of World Academy of Science Engineering and Technology, vol. 4, February 2005 ISSN

1307-6884.)

8.) Nafiz Arica at al. proposed a method which avoids most of the pre-processing operations, which causes loss of important information. One of the major contributions of the method is to development of a powerful segmentation algorithm. Utilization of the character boundaries, local maxima and minima, slant angle, upper and lower baselines, stroke height and width, and ascenders and descenders improve the search algorithm of the optimal segmentation path, applied on a gray-scale image. This approach decreases the over-segmentation. Another contribution is the use of Hidden Markov Models (HMM) training, not only for the estimation of model parameters, but also for the estimation of some global and feature space parameters. Also, HMM probabilities are used to measure the shape

information and rank the candidate character. One dimensional representation of a two dimensional character image increases the power of the HMM shape recognizer.

(Nafiz Arica, and Fatos T. Yarman-Vural, ―Optical Character Recognition for Cursive Handwriting,‖ IEEE Transactions on Pattern Analysis and Machine Intelligence, vol.24, no.6, pp. 801-113.)

9.) Ashutosh Aggarwal et al[12] propose a method for Isolated Handwritten Devanagari Character Recognition. Binarization, noise removal and skeletonization are used as preprocessing steps. Thresholding is used as bianarization, median filter used for salt and pepper noise removal. Horizontal and vertical segmentations are used to select individual character. Gradient methods are used as Feature Extraction. The obtained feature is passed to SVM for classification. It gives the recognition efficiency of 94%.

(Ashutosh Aggarwal, Rajneesh Rani and RenuDhir,"Handwritten Devanagari Character Recognition Using Gradient Features", Pattern Recognition (ICPR), pp: 621-624, 2012.)

10.) Karanbir Kaur had taken care of English handwritten character recognition. Introduce image cropping, gray the image and binarization as preprocessing steps. 40-point feature extraction is introduced for extracting the features of the handwritten alphabets. ANN is used for classification.

(Karanbir Kaur and Naresh kumar Garg,"Use of 40-point Feature Extraction for Recognition of Handwritten Numerals and English Characters", IJCTA, pp: 1409-1414, 2014)

11.) Identification of different handwritten cursive alphabets is proposed in research work carried out . In this method various characteristics are extracted between them, two features customized edge map and multiple zoning are projected by writers. 9 characteristics are extracted and disadvantage of every characteristic is defeats by alternative. Every characteristic are independently provided as input to 9 multi layer perceptron network and outcomes this classifier are merged with every alternative by various law similar to max, mean, product and sum rule etc amongst them trained MLP merger provides highest

outcome. Between projected characteristics customized edge map characteristic provides maximum outcome.

(Cruz, Rafael MO, George DC Cavalcanti, and Tsang Ing Ren. "An ensemble classifier for offline cursive character recognition using multiple feature extraction techniques." In Neural Networks (IJCNN), The 2010 International Joint Conference on, pp. 1-8. Ieee, 2010.)

12.)Yoshimasa Kimura presented a work on how to selectfeatures for Character Recognition Using Genetic Algorithm.The author proposes a novel method of feature selection for character recognition using genetic algorithms (GA). The proposed method selects only the genes for which the recognition rate of training samples exceeds than the predetermined threshold as a candidate of the parent gene and adopts a reduction ratio in the number of features used for recognition as the fitness value.

(Yoshimasa Kimura, "Feature Selection for Character Recognition Using Genetic Algorithm", Fourth International Conference on Innovative Computing, Information and Control 978-0-7695-3873-0/09© 2009 IEEE, 2009.)

13.)Renata F. P. Neves have proposed SVM based offline handwritten digit recognition. Authors claim that SVM outperforms the Multilayer perceptron classifier. Experiment is carried out on NIST SD19 standard dataset. Advantage of MLP is that it is able to segment non-linearly separable classes. However, MLP can easily fall into a region of local minimum, where the training will stop assuming it has achieved an optimal point in the error surface. Another hindrance is defining the best network architecture to solve the problem, considering the number of layers and the number of perceptron in each hidden layer. Because of these disadvantages, a digit recognizer using the MLP structure may not produce the desired low error rate.

(Renata F. P. Neves, Alberto N. G. Lopes Filho, Carlos A.B.Mello,Cleber Zanchettin, “A SVM Based Off-Line Handwritten Digit Recognizer”, International conference on Systems, Man and Cybernetics, IEEE Xplore, pp. 510-515, 9-12 Oct, 2011, Brazil.)

Method	Accuracy	Purpose
Hand printed symbol recognition.	97% overall.	Extract the geometrical, topological and local measurements required to identify the character.
OCR for cursive handwriting.	88.8% for lexicon size 40,000.	To implement segmentation and recognition algorithms for cursive handwriting.
Recognition of handwritten numerals based upon fuzzy model.	95% for Hindi and 98.4% for English numerals overall.	The aim is to utilize the fuzzy technique to recognize handwritten numerals for Hindi and English numerals.
Combining decision of multiple connectionist classifiers for Devanagari numeral recognition.	89.6% overall.	To use a reliable and an efficient technique for classifying numerals.
Hill climbing algorithm for handwritten character recognition	93% for uppercase letters.	To implement hill climbing algorithm for selecting feature subset.
Optimization of feature selection for recognition of Arabic characters	88% for numbers and 70% for letters.	To implement hill climbing algorithm for selecting feature subset.
Handwritten numeral recognition for six popular Indian scripts	99.56% for Devanagari, 98.99% for Bangla, 99.37% for Telugu, 98.40% for Oriya, 98.71% for Kannada and 98.51% for Tamil overall.	To implement hill climbing algorithm for selecting feature subset.

IMPLEMENTATION

1.) Convolutional neural network

Human brain is a very powerful machine. We see multiple images every second and process them without realizing how the processing is done. But this is not the case with machines. The first step in image processing or character recognition is to understand, how to represent an image so that a machine can read it. In simple term, image is a collection of dots (pixels) arranged in a order. If you change the order or colour of a pixel, the image would change as well. All CNN models follow a similar architecture, as shown below. There is an input image that we are working with and then perform a series of convolution, pooling operations followed by a number of fully connected layers.

2.) Image pre-processing

Pre-processing is the basic phase of character recognition and it's crucial for good recognition rate. The main objective of pre-processing steps is to normalize strokes and remove variations that would otherwise complicate recognition and reduce the recognition rate. These variations or distortions include the irregular size of text, missing points during pen movement collections, jitter present in text, left or right bend in handwriting and uneven distances of points from neighbouring positions. Pre-processing includes five common steps, namely, size normalization and centering, interpolating missing points, smoothing, slant correction and resampling of points.

3.)Feature Extraction

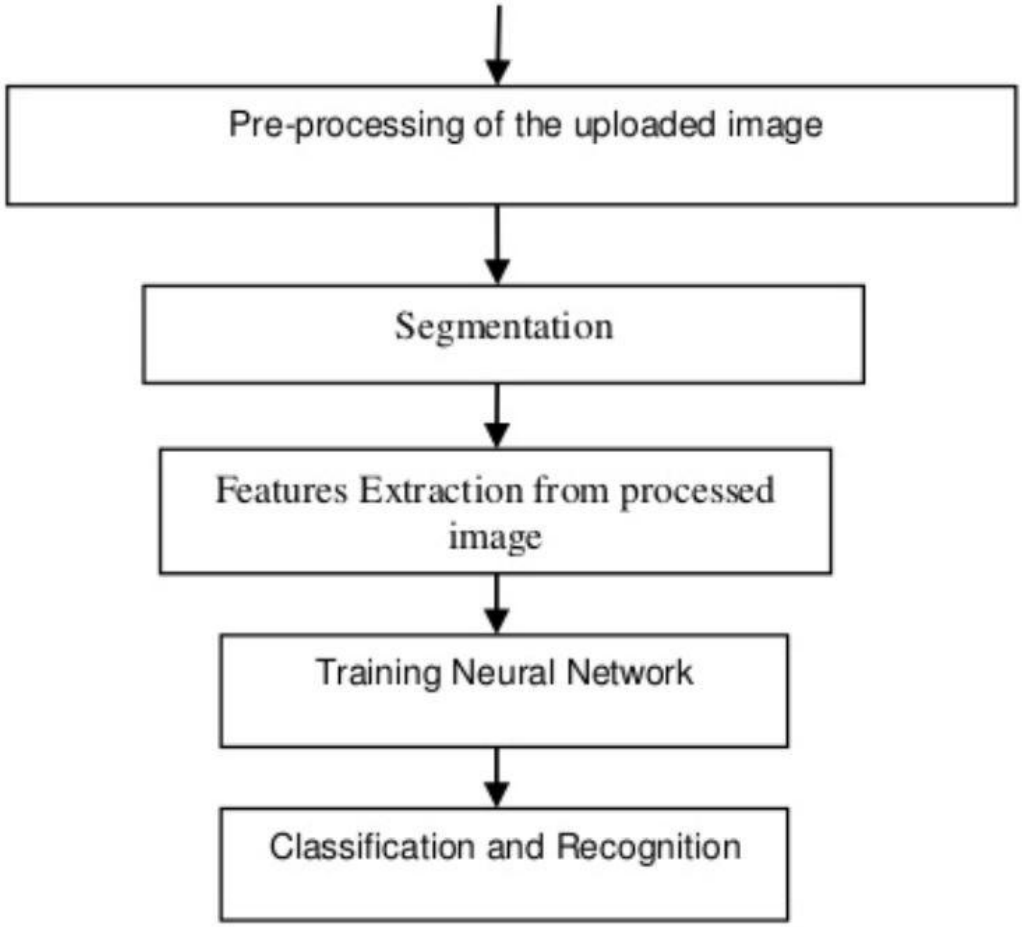
The purpose of feature extraction is the measurement of those attributes of patterns that are most pertinent to a given classification task. The task of the human expert is to select or invent features that allow effective and efficient recognition of patterns. Many features have been discovered and used in pattern recognition.

4.) Classification

When input image is presented to HCR system, its features are extracted and given as an input to the trained classifier like artificial neural network or support vector machine. Classifiers compare the input feature with stored pattern and find out the best matching class for input.

5.)Post Processing

Post-processing refers to the procedure of correcting misclassified results by applying linguistic knowledge. Post-processing is processing of the output from shape recognition. Language information can increase the accuracy obtained by pure shape recognition. For handwriting input, some shape recognizers yield a single string of characters, while others yield a number of alternatives for each character, often with a measure of confidence for each alternative.



ALGORITHM:-

For this task we build a convolution neural network (CNN) in Keras using Tensorflow backend. We will use a standard CNN with multiple convolution and maxpool layers, a few dense layers and a final output layer with softmax activation. RELU activation was used between the convolution and dense layers and model was optimized using Adam optimizer.

Convolutional neural networks are more complex than standard multi-layer perceptrons, so we will start by using a simple structure to begin with that uses all of the elements for state of the art results. Below summarizes the network architecture.

1.) The first hidden layer is a convolutional layer called a Convolution2D. The layer has 32 feature maps, which with the size of 5×5 and a rectifier activation function. This is the input layer, expecting images with the structure outline above [pixels][width][height].

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3.)The next layer is a regularization layer using dropout called Dropout. It is configured to randomly exclude 20% of neurons in the layer in order to reduce overfitting.

4.)Next is a layer that converts the 2D matrix data to a vector called Flatten. It allows the output to be processed by standard fully connected layers.

5.)Next a fully connected layer with 128 neurons and rectifier activation function.

6.)Finally, the output layer has 10 neurons for the 10 classes and a softmax activation function to output probability-like predictions for each class.
As before, the model is trained using logarithmic loss and the ADAM gradient descent algorithm

The size of the model needs to be proportional to the size of the data. Three blocks of convolution -maxpool layers and couple of dense layers was sufficient for this problem. See model summary below:

```
Using TensorFlow backend.
_________________________________________________________________
Layer (type)                 Output Shape              Param #
=================================================================
conv2d_1 (Conv2D)            (None, 28, 28, 32)        320
_________________________________________________________________
conv2d_2 (Conv2D)            (None, 28, 28, 32)        9248
_________________________________________________________________
max_pooling2d_1 (MaxPooling2 (None, 14, 14, 32)        0
_________________________________________________________________
conv2d_3 (Conv2D)            (None, 14, 14, 62)        17918
_________________________________________________________________
conv2d_4 (Conv2D)            (None, 14, 14, 62)        34658
_________________________________________________________________
conv2d_5 (Conv2D)            (None, 14, 14, 62)        34658
_________________________________________________________________
max_pooling2d_2 (MaxPooling2 (None, 7, 7, 62)          0
_________________________________________________________________
max_pooling2d_3 (MaxPooling2 (None, 3, 3, 62)          0
_________________________________________________________________
conv2d_6 (Conv2D)            (None, 3, 3, 32)          17888
_________________________________________________________________
conv2d_7 (Conv2D)            (None, 3, 3, 16)          4624
_________________________________________________________________
max_pooling2d_4 (MaxPooling2 (None, 1, 1, 16)          0
_________________________________________________________________
flatten_1 (Flatten)          (None, 16)                0
_________________________________________________________________
dense_1 (Dense)              (None, 512)               8704
_________________________________________________________________
dense_2 (Dense)              (None, 1024)              525312
_________________________________________________________________
dense_3 (Dense)              (None, 100)               102500
_________________________________________________________________
dense_4 (Dense)              (None, 10)                1010
=================================================================
Total params: 756,840
Trainable params: 756,840
Non-trainable params: 0
```

Result Analysis

Artificial Intelligence is a constantly evolving field and there is always room for improvement in your methodology; there is always going to be another new approach that gives better results for the same problem. The application has been tested using three models: Multi-Layer Perceptron (MLP), Convolution Neural Network (CNN). With each model we get a different accuracy of the classifier which shows which one is better. The results of training the network is stored in .npz format so that whenever a user tries to recognize the digit, the application does not go into the training loop again. For classification, we have used logistic classifier, softmax function, one hot encoding, cross entropy and loss minimization using mini batch gradient descent. These are some of the basics of Neural Network which are required to process the output from the network and display in the form the user can understand.

Dataset used:

The dataset used is the MNIST database of handwritten digits.It consists of a training set of 60,000 examples, and a test set of 10,000 examples.The digits have been size-normalized and centered in a fixed-size image.The images are of size 28*28 pixels.It is a good database for people who want to try learning techniques and pattern recognition methods on real-world data while spending minimal efforts on preprocessing and formatting.

FUTURE WORK:-

Fixed size Convolutional Neural Networks has been applied to many applications like handwritten digit recognition , machine printed character recognition and on-line handwriting recognition, they can also be useful for signature verification .The more the training examples the more is the accuracy of the networks .Unsupersived machine learning was made easier using Convolutional Neural networks , some of the future works possible to implement by CNN's are compressing or obtaining same results from smaller networks by optimization tricks , more invariant feature learning such that the input images dosen't gets distorted. The major 3D vision networks is a scope for researches to develop using LeNet architecture and more biologically concordant methods , a hope for future is that Unsupervised CNN's.

References:-

[1.] A Review of Various Handwriting Recognition Methods Salma Shofia Rosyda1 and Tito Waluyo Purboyo 2 1,2 Department of Computer Engineering, Faculty of Electrical Engineering, Telkom University, Bandung, West Java, Indonesia.

[2.]Hand Written Digit Recognition using Convolutional Neural Network (CNN) Nimisha Jain1 , Kumar Rahul1 , Ipshita Khamaru1 . Anish Kumar Jha1 , Anupam Ghosh1* 1 Department of Computer Sc. & Engineering, Netaji Subhash Engineering College, Kolkata

[3.]Isha Vats, Shamandeep Singh, "Offline Handwritten English Numerals Recognition using Correlation Method",InternationalJournal of Engineering Research and Technology (IJERT): ISSN: 2278-0181 Vol. 3 Issue 6, June 2014. Access Date: 09/07/2015

[4.]Prof. Swapna Borde, Ms. Ekta Shah, Ms. Priti Rawat, Ms. Vinaya Patil, "Fuzzy Based Handwritten Character Recognition System" ,International Journal of Engineering Research and Applications (IJERA) ISSN: 2248-9622,VNCET 30 Mar'12. Access Date: 09/07/2015.

[5.]Mitrakshi B. Patil, Vaibhav Narawade, "Recognition of Handwritten Devnagari Characters through Segmentation and Artificial neural networks" ,International Journal of Engineering Research and Technology (IJERT) Vol. 1 Issue 6, August - 2012. ISSN: 2278-0181. Access Date:09/07/2015.

[6.]Nisha Sharma et al, "Recognition for handwritten English letters: A Review"International Journal of Engineering and Innovative Technology (IJEIT) Volume 2, Issue 7, January 2013. Access Date:09/07/2015.

[7.]DR.KUSUMGUPTA2 ,"A comprehensive review on Handwritten Digit Recognition using various Neutral Network Approaches",International Journal of Enhanced research in Management &Computer Applications,VOL. 5, NO. 5, PP. 22-25, 2016

[8.]Darmatasia and Mohamad Ivan Fanany. "Handwriting Recognition on Form Document Using Convolutional Neural Network and Support Vector Machines (CNNSVM)", Fifth International Conference on Information and Communication Technology (ICoICT), 2017.