VISVESVARAYA TECHNOLOGICAL UNIVERSITY
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A synopsis on

South Indian Recipe Recommendation from Ingredient Image

Submitted by

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TABLE OF CONTENTS

Sl No.	Title	Page No.
1	**Abstract**	1
2	**Introduction**	2
3	**Design**	6
4	**Implementation**	8
5	**Conclusion**	11
6	**References**	12
7	**PO Attainment**	14
8	**Details of list of publications related to this project**	15

1. Abstract

Women have experienced all aspects of life, from grandeur and respect during the Vedic period to denial and servitude during the post-Vedic period. They even fought for the modern-day struggle for equality, acknowledgment, and existence. Violence, physical abuse, denial of the right to life, subordination, and neglect have all been perpetrated against women. Eve-teasing, molestation, sexual assault, and rape are examples of abuses that are frequently referred to as sexual harassment or sexual misbehaviour.

The evidence is all around us; women's voices are increasingly being heard in Parliament, the courts, and on the streets. From the beginning, India's Constitution granted women equal rights to males. Unfortunately, owing to illiteracy and restrictive traditions, most women in this country are uninformed of their rights. In India, there have been around 32000 murders, 19,000 rapes, 7500 dowry deaths, and 36500 molestation instances registered against women, and these are the approximate numbers, which are rising by the day. And these are only the incidents that have been recorded; most rapes and molestation crimes go unreported owing to the risk of losing family reputation in the society.

2. Introduction

2.1 Overview

Today in the current global scenario, the prime question in every girl's mind, considering the ever-rising increase of issues on women harassment in the recent past, is mostly about her safety and security. The only thought haunting every girl is when they will be able to move freely on the streets even in odd hours without worrying about their security. This paper suggests a new perspective to use technology for women safety. "848 Indian Women Are Harassed, Raped, Killed Every Day!!" That's way beyond a HUGE number! We propose an idea which changes the way everyone thinks about women safety. A day when the media broadcasts more of women's achievements rather than harassment, it's a feat achieved! Since we (humans) can't respond aptly in critical situations, the need for a device which automatically senses and rescues the victim is the venture of our idea in this paper. We propose to have a device which is the integration of multiple devices, hardware consisting of a wearable "Smart band" which continuously communicates with Smartphones that have access to the internet. The application is programmed and loaded with all the required data which includes Human behavior and reactions to different situations like anger, fear and anxiety. This generates a signal which is transmitted to the smartphone. The software or application has access to Messaging services which are pre-programmed in such a way that whenever it receives an emergency signal, it can send help requests along with the location coordinates to the nearest Police station, relatives and the people in the near radius who have application. This action enables help instantaneously from the Public in the near radius who can reach the victim with great accuracy.

2.2 Motivation

Our project focuses on a security system that is designed merely to serve the purpose of providing security to women so that they never feel helpless while facing such social challenges. An advanced system can be built that can detect the location of a person that will enable us to take action accordingly based on electronic gadgets like GSM, Accelerometer sensor. We can make use of a number of sensors to precisely detect the real time situation of the women in critical abusive situations. The gadgets help make decisions along with other sensors like Accelerometer sensors to detect the abnormal motion of the women while she is victimized. The idea to develop a smart device for women is that it's completely comfortable and easy to use as compared with already existing women security solutions such as a separate garment, bulky belts and infamous mobile apps that are just very abstract and obsolete. The Smart band integrated with Smart phone has an added advantage so as to reduce the cost of the device and also in reduced size.

2.3 Objective

The device communicates with a laptop through a specially designed program that acts as an interface between the device and the laptop. The data directed by the smart band such as the pulse rate, temperature of the body along with the motion of the body is continuously monitored. In cases of abuse, the laptop directs the device to perform the following tasks:

- Send messages to the family members along with the coordinates.
- Also sends information to people in the near vicinity requesting public attention.

2.4 Scope

The proposed design will deal with critical issues faced by women in the near past and will help to solve them with technologically sound equipment and ideas. This system can overcome the fear that scares every woman in the country about her safety and security.

2.5 Existing System

Having this concern in mind many developers have come up with creative applications. Some of such applications are: Codes like *91# is used to provide emergency services, which will alert police control. Free mobile application 'Help me on mobile' to ensure safety of women was launched to assist those who need emergency care. These applications need a single click to do this task. But when a girl is in trouble, there can be times that the girl is not capable of taking the phone and pressing the button.

2.6 Proposed System

The device communicates with a laptop through a specially designed program that acts as an interface between the device and the laptop. The data directed by the smart band such as the pulse rate, temperature of the body along with the motion of the body is continuously monitored. In cases of abuse, the laptop directs the device to perform the following tasks:

- Send messages to the family members along with the coordinates.
- Also sends information to people in the near vicinity requesting public attention.

3. Design

3.1 High Level Design

The complete system is mainly about safeguarding the women. The input to the whole system is sensed by the device, the inputs are the state of the panic button, accelerometer vibration, body temperature and heart beat rate. All of these are processed and by the device and machine learning is applied. And the output is if the person is in danger or safe or has had some health issues. Accordings message has to be sent.

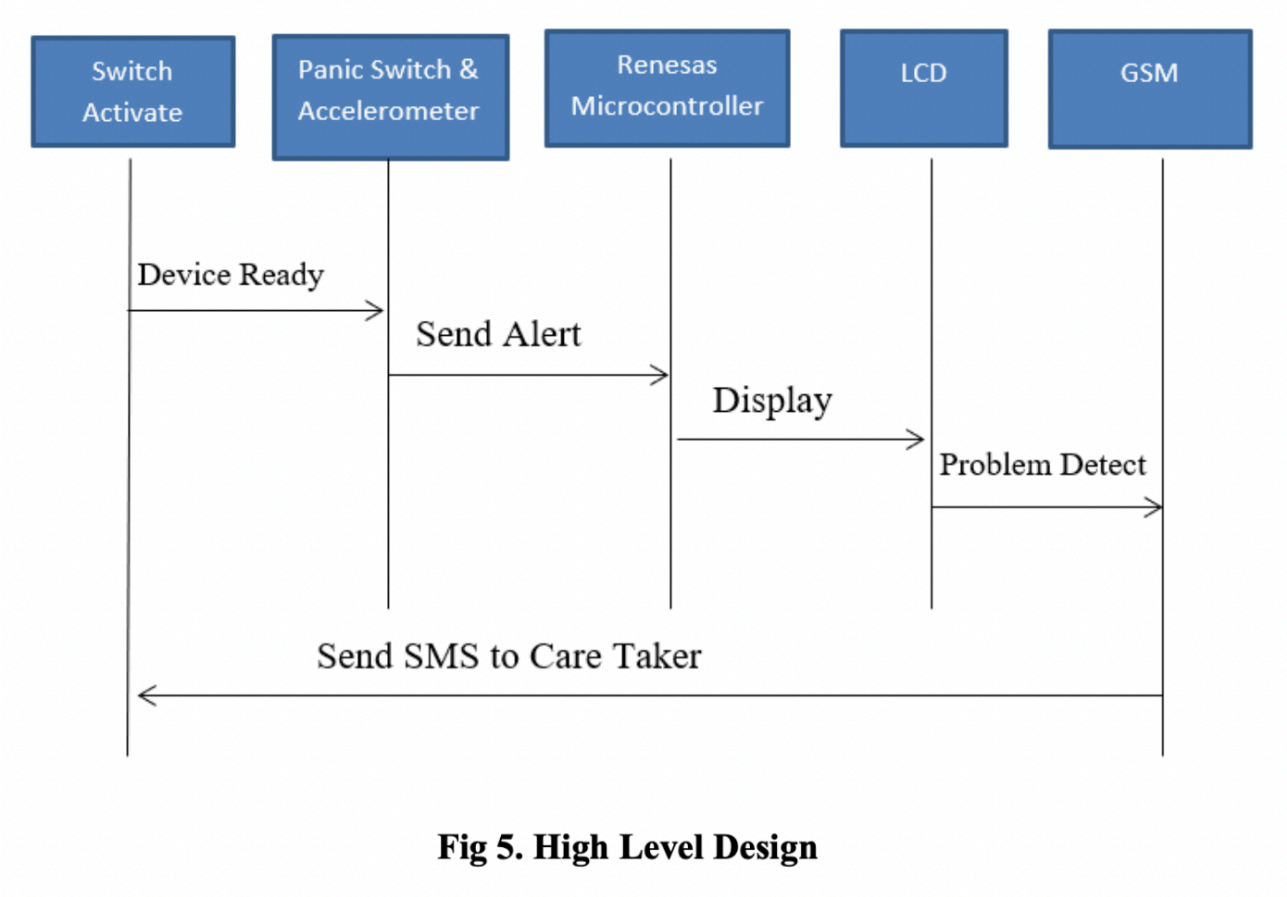

Fig 5. High Level Design

3.2 System Architecture

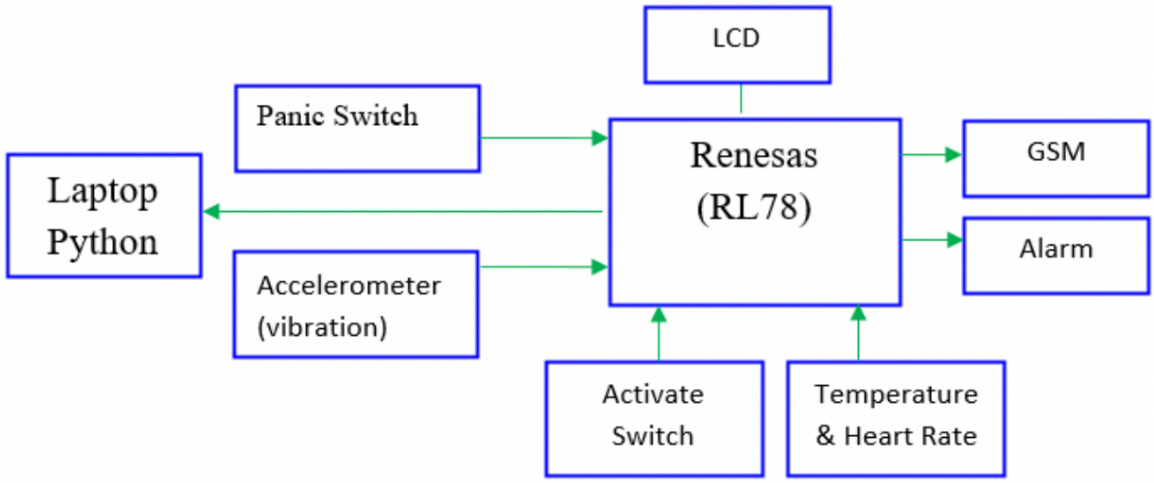

Fig 6. System Architecture of the proposed system

Systems can be divided mainly into two subsystems. The hardware device is used by the user mainly for sensing and processing. Renesas microcontroller is used. And the other part is the machine learning processing which uses two main algorithms: logistic regression and KNN.

4. Implementation

4.1 Overview of Technologies Used

Technologies used include:

- **Python**: Python is a dynamic language which is interpreted line by line and not compiled. Python is a strongly typed language and high-level language which makes it easy to understand. It supports object-oriented programming, functional programming and procedural programming. Python is especially preferred for implementing machine learning projects since it supports a variety of popular machine learning libraries like TensorFlow, matplotlib, sklearn, surprise, pandas, numpy, all of which were used to implement this project.
- **Renesas Microcontroller:**The figure 3 shows the R5F100LEA microcontroller from Renesas RL78 series which is a 16-bit microcontroller used to implement this project. Microcontroller acts as the heart of the project, which controls the whole system. It contains of Flash ROM 64KB, RAM 4KB and Data Flash 4KB, and it has High speed on-chip oscillator, Self-reprogrammable under software control, 58 GPIO's, 3 UART's, Simplified I2C, 10 bit resolution ADC, 28 Interrupt Sources, ISP programming support etc.
- **Embedded C** is a set of language extensions for the C programming language by the C Standards Committee to address commonality issues that exist between C extensions for different embedded systems. Embedded C programming typically requires nonstandard extensions to the C language in order to support enhanced microprocessor features such as fixed-point arithmetic, multiple distinct memory banks, and basic I/O operations.
- **Pandas**: pandas is a software library written for the Python programming language for data manipulation and analysis. In particular, it offers data structures and operations for manipulating numerical tables and time series.

- **PySerial** is a library which provides support for serial connections ("RS-232") over a variety of different devices: old-style serial ports, Bluetooth dongles, infra-red ports, and so on. It also supports remote serial ports via RFC 2217 With the **xlrd** and **xlwt** Python Addon libraries you can easily read and write directly to Excel files.

4.2 Implementation details of modules

4.2.1 Prediction System

• Preparing the dataset

We have prepared the data set for determining the state of the user using the device depending on certain parameters. The parameters considered for the data set are as follows

1. Accelerometer reading of X axis
2. Accelerometer reading of Y axis
3. Temperature
4. Heart rate
5. Panic switch state

The output classes for this dataset are:

1. 0 - Problem detected
2. 1 - Person is safe
3. 2 - Problem detected along with health issue detected

• Building Model

We mainly used two algorithms for the prediction.

KNN:K-nearest neighbors (KNN) algorithm uses ‘feature similarity’ to predict the values of new data points which further means that the new data point will be assigned a value based on how closely it matches the points in the training set.

Logistic regression: Logistic regression is a process of modeling the probability of a discrete outcome given an input variable.

We made use of Python libraries such as PySerial, xlrd, xlwt, numpy, matplotlib, seaborn, scikit learn, pandas etc

```
 test_X =
     PanicSwitch  Accelerometer X  Accelerometer Y  Temperature  HeartRate
20             1               130              190           31         72
89             1               134              188           33         73
73             0               152              165           31         73
59             0               155              165           32         71
37             0               155              165           30         71
15             1               140              190           41         79
51             0               160              165           29         71
36             1               134              188           33         73
26             1               135              185           28         71
33             0               152              165           31         73
13             0               152              165           31         73
22             1               145              186           38         77
64             1               134              188           30         71
12             1               135              185           29         72
58             1               135              188           36         76
40             1               132              188           30         71
11             0               160              165           29         71
62             1               140              186           38         77
18             1               144              188           36         76
```

```
 test_X =
     PanicSwitch  Accelerometer X  Accelerometer Y  Temperature  HeartRate
20             1               130              190           31         72
89             1               134              188           33         73
73             0               152              165           31         73
59             0               155              165           32         71
37             0               155              165           30         71
15             1               140              190           41         79
51             0               160              165           29         71
36             1               134              188           33         73
26             1               135              185           28         71
33             0               152              165           31         73
13             0               152              165           31         73
22             1               145              186           38         77
64             1               134              188           30         71
12             1               135              185           29         72
58             1               135              188           36         76
40             1               132              188           30         71
11             0               160              165           29         71
62             1               140              186           38         77
18             1               144              188           36         76
```

```
 train_y =
 90    0
2     2
17    0
66    1
5     0
     ..
83    2
67    0
25    0
68    2
47    0
Name: OutputClass, Length: 74, dtype: int64
```

Fig 10: Train and test dataset splitting

- Testing the model we have used two algorithms: KNN and Logistic regression. As we can see in the figure the accuracy of both the algorithms is 94 percent.

```
Name: OutputClass, dtype: int64
LR Alg Accuracy 94 Percent
Output Prediction LR =  [1 1 0 0 0]


 20    1
89     0
73     0
59     0
37     0
15     2
51     0
36     1
26     1
33     0
Name: OutputClass, dtype: int64
KNN Alg Accuracy 94 Percent
Output Prediction KNN =  [1 1 0 0 0]
```

Fig 11: Algorithm accuracy rate

5. Conclusion and Future Enhancements

5.1 Conclusion

This type of an idea being the first of its kind plays a crucial role towards ensuring Women Safety in the fastest way possible automatically. The proposed design will deal with critical issues faced by women in the recent past and will help solve them through technologically sound gadgets. With further research and innovation, this project can be implemented in different areas of security and surveillance. The system can perform the real time monitoring of desired areas and detect the violence with a good accuracy.

5.2 Future Enhancements

With further research and innovation, this project can be implemented in different areas of security and surveillance. The system can perform the real time monitoring of desired areas and detect the violence with a good accuracy.

6. References

[1]A STUDY ON SEXUAL HARASSMENT ON WOMEN IN INDIA by Madhu Balaaji and S. Malaimagal.
https://journalijcar.org/issues/study-sexual-harassment-women-india

[2]Women's Safety and Tracking System with GSM AND GPS Atharv Parbalkar, Shwetambari Belote , Shreyas Dharyekar , Amol Dhanawade , Heena Pyare
https://www.academia.edu/52290528/Womens_Safety_and_Tracking_System_with_GSM_AND_GPS

[3]Women's Perceptions of Safety After Domestic Violence: Exploring Experiences of a Safety Contact Program Tania Westwood , Sarah Wendt and Kate Seymour
https://doi.org/10.1177/0886109919873904

[4] Women safety device and application-FEMME Article in Indian Journal of Science and Technology
https://www.researchgate.net/publication/299404936

[5] WOMEN SAFETY DEVICE BASED ON "INTERNET OF THINGS (IOT)" Urmilla Pilania ,Aishwarya Nair,Sakshi Arora,Virender Kadian Department of CSE , Manav Rachna University, Faridabad, Harayana, India
https://www.jetir.org/papers/JETIRA006152.pdf

[6]AbhijitParadkar, Deepak Sharma, All in one Intelligent Safety for Women Security, Department of ME, K.J.SomaiyaColege of Engg, Mumbai, India, Volume 130- No.11
https://www.ijcaonline.org/research/volume130/number11/paradkar-2015-ijca-907144.pdf

[7]My Safetipin Mobile Phone Application: Case Study of E-Participation Platform for Women Safety in India Article in Journal of Scientometric Research
https://www.researchgate.net/publication/332833226

[8]ANDROID APP FOR WOMEN SECURITY SYSTEM R. HARINI ; P. HEMASHREE IJCSMC, Vol. 8, Issue. 10, October 2019
https://www.academia.edu/40606657/ANDROID_APP_FOR_WOMEN_SECURITY_SYSTEM_#:~:text=The%20Project%20entitled%20as%20%E2%80%9CAndroid%20App%20for%20Women,SMS%2C%20contacts%2C%20GPS%20to%20enhance%20the%20security%20feature.
[9]ABHAYA: AN ANDROID APP FOR THE SAFETY OF WOMEN
https://www.researchgate.net/publication/287201587_Abhaya_An_Android_App_For_The_Safety_Of_Women
[10] An Android Based Application for Women Security
https://ijesc.org/upload/4c1bdc0297527339c6423e7045879c94.An%20Android%20Based%20Application%20for%20Women%20Security.pdf

7. PO Attainment

BMS College of Engineering. Department of Computer Science and Engineering.

Batch No.: B34 Date: 18-06-2020 Project Title: South Indian Recipe Recommendation from Ingredient Image

PROGRAMME Level OUTCOMES (1/2/3)

PO1 3

PO2 3 **PO3** 2 **PO4** 3 **PO5** 3

PO6 1 **PO7** 1

Justification if addressed

Collaborative Filtering and CNN models required extensive use of data structures and algorithms.

Image Classification and Recommendation
Client-Server Architecture.

Methods based on research were studied.
Used Google Colab to design deep learning models.
The project can further be extended to improve the cooking experience

The project does not have negative effects on environment Measures are taken so that the project is ethical to the best of our knowledge

3 Every team member contributed to the project and discharged his duties well.

PO10 3 **PO11** 2 **PO12** 3

PSO1 3 **PSO2** 2

PSO3 3 Submitted by:

USN

1BM16CS063 1BM16CS065 1BM16CS068 1BM16CS125

Published a paper.

Effectively communicated and presented results.
This project enabled us to expand our knowledge of current trends in deep learning.
Knowledge of full stack development applied to create a mobile application.

Developed Mobile application to help users interact. Efficient code was produced to solve the problem

STUDENT NAME

Nitish Vivian Maximus Parva Chauhan Praguna Manvi
Vishnu M P

SIGNATURE

14

8. Details of list of publications related to this project 8.1 Research Paper

SOUTH INDIAN RECIPE RECOMMENDATION FROM INGREDIENT IMAGE

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Abstract— **Applications involving ingredient recognition are very limited and mostly do not work in less ideal conditions like the ones faced in a typical kitchen. The main reason for this is the dataset that the existing models are based on. These datasets do not account for real world factors like noise, blur, etc. in the input image, since they are trained on images obtained from controlled and nearly idealistic environments. For these reasons we create our own dataset, consisting of real-world images which represent the scenarios users are most likely to face during daily use. We develop a simple and robust system that aims to address this issue. We make use of a multi-label classification model to identify multiple ingredients from a single image, which are the most likely kind of images to be encountered in a kitchen environment. We develop a personalized recommendation system that recommends a list of South Indian recipes to users based on the ingredients identified. Recommendation makes use of ratings and reviews submitted for the South Indian recipes by the users.**

Keywords— Ingredients, recipe, multi-ingredient dataset, recommendation, multi-label classification, Recipe Recommendation

I. INTRODUCTION

Deciding which dish to prepare with available ingredients is a problem that everybody can relate to. This project aims to alleviate that problem and expedite the cooking process by providing a simple and robust solution which helps the user by providing a list of South Indian dishes along with their recipes based on the image of ingredients available.

The majority of research on ingredient identification is usually conducted in environments in which backgrounds, lighting and even framing of the ingredients in the image is controlled and these result in idealistic scenarios, which as we know is not always the case. The most common scenarios however do not possess many of the traits of ideal scenarios and result in input images which are blurry, low resolution or even distorted.

In this paper we present a multiple ingredient recognition solution using a multi-label classification network and a recommendation system to recommend users a list of South Indian recipes based on the identified ingredients from the input image.

To aid the process of training and execution of this task, we collect a multi-class (vegetables, fruits, spices, etc.) image dataset that is captured under varying kitchen environments.

The workflow of the proposed system is shown in Fig 1.

We summarize our work as follows:

- We showcase a new multi-class ingredient image dataset captured in a kitchen environment and South Indian recipe and reviews dataset to enable more research.
- We have developed a multi ingredient classification system based on the dataset constructed.
- We have developed a personalized recipe recommendation system for South Indian recipes based on ratings collected.

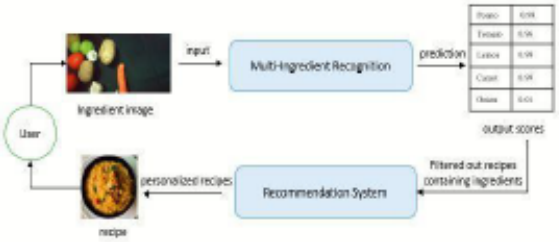

Fig 1. Recipe Recommendation from Ingredient image

II. RELATED WORK

A. Multi-ingredient Image Recognition

This paper [1] proposes a system which can identify multiple ingredients present in an image and also recommend recipes based on the results of identification. They make use of Spatial Regularization Networks for ingredient recognition. The dataset is constructed in a supermarket environment. Recommendation uses Neural collaborative filtering method.

B. Multi-label Image Classification (MLIC)

The approach used in this paper [2] is among the first Deep Neural Network based label embedding frameworks for multi-label classification. This paper makes use of an approach called Canonical Correlated AutoEncoder to achieve the task of multi-label classification with more accuracy through better relating of features with label domain data. The model is trained to learn from an image label space and then predict labels accordingly. The proposed method also works with training data that has labels missing.

C. Recommendation of Recipes

This paper [3] proposes a unique method of recommending recipes using Machine learning models and Bayesian Optimization, rather than Collaborative Filtering which is a widespread approach. This method is unique and fast in that it does not wait to get real world data and uses simulated data for training the model. This saves a lot of time and an accurate model can be developed quickly and with lesser human resources.

D. Ingredient Recognition

The approach in [4] compares several image descriptors and then chooses a suitable combination. It makes use of feature fusion which combines more than one feature to provide a feature vector that can be better used for recognition. Preprocessing of images includes segmentation of the object in the picture from the background. This approach uses Convolutional Neural Networks to build a model that can identify the fruits or vegetables in the given input image.

III. INGREDIENT RECOGNITION

A. KC47 Kitchen Dataset

The ingredient datasets that are currently available contain images of only a single class. Hence, the ingredient classification models generated by these datasets cannot handle real world scenarios, such as kitchen environments, with much accuracy. We have prepared a Multi-Class image dataset consisting of 47 classes that include vegetables, fruits, spices and pulses, set in a kitchen environment to meet our requirements.

The following are some unique aspects of this dataset:

- Images in our dataset are captured in varying conditions and backgrounds, with ingredients kept on countertops, wooden table, white sheet and table cloth in both low and high light exposures.
- There are a varying number of classes for each image instance.
- Images are captured using 3 different smartphones. These images have a resolution equal to the image captured by current mainstream smartphones.
- Images have resolutions ranging from 1500 x 1500 to 4600 x 3500.

We have captured 3228 train images and 933 test images through our collection procedure. Fig 2 represents a sample of images from the KC47 dataset and shows an example of the distinct classes present in the KC47 dataset and the frequency distribution of the 47 ingredients is shown in Fig 3.

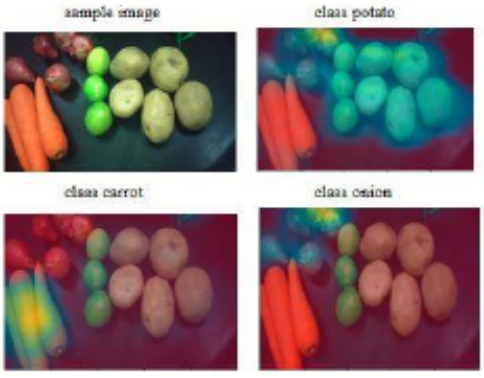

Fig 2. Sample Image from KC47 dataset with identified classes

B. Multi-Ingredient Image Recognition

Multi-Ingredient recognition is a multi-class classification problem on the ingredient images captured in a regular kitchen environment. The classification models are trained on the KC47 dataset.

We have experimented with various state of the art approaches on the dataset. The approaches used in this work are: Resnet-101[5], a deep network which overcomes vanishing gradients problem using residual blocks. InceptionV3[6], a computationally efficient approach with aggressive regularization. InceptionResnet [7], combines the above two approaches. DenseNet [8], a computational and memory efficient approach consisting of connected dense blocks.

All the experimented approaches are transfer learned on imagenet weights. The varying input images while training is resized to 1000 x 1000 aspect ratio. The implementation of models is made in Keras and TensorFlow. In order to avoid overtraining, data augmentation is performed. The loss function binary cross entropy is used while training. Adam optimizer and optimized learning rates have been employed.

Fig 3. List of ingredients

IV. RECOMMENDATION

A. South Indian Recipes and Reviews Dataset

We have constructed a South Indian recipe dataset by taking recipes of dishes from various websites. We currently have 126 South Indian recipes in our dataset.

The rating dataset has been constructed by collecting user responses through a web application [9]. It was developed using the MERN (MongoDB Express ReactJS NodeJS) stack. During the data collection process, duplicate responses with the same IP address were allowed. The respondents rated the dishes from the South Indian Recipe Dataset on the scale of 1 to 5.

The South Indian Recipe Dataset has 126 dishes. We have received 1502 responses. Each respondent was asked to rate at least five dishes of their choice while submitting their responses. Figure 4 shows the distribution of the number of

ratings per respondent in the dataset. It can be observed that the mean value lies between 5 and 8 responses.

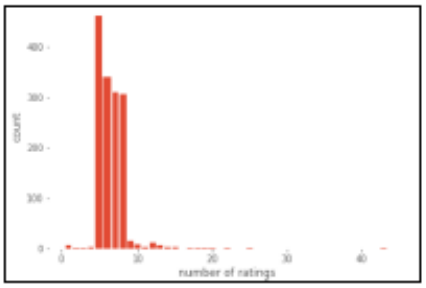

Fig 4. Distribution of number of ratings per respondent

C. Recommendation Model

The recommendation model is aimed at understanding the user's preference of dishes and to provide them with recommendations. The recipes are filtered out using the recognized ingredients. Recommendation is performed from these recipes.

Content-based and collaborative filtering (CF) [10] are common solutions in the recommendation domain. However, since there is a dearth of interaction, the implicit connection that exists among users and recipes is difficult to uncover when using the traditional CF method.

The two main types of CF are: (i) UserCF: measures how similar two users are and recommends items that these similar users liked. (ii) ItemCF: measures the similarity of ratings of different items and recommend items that are similar. There are a few issues that result when using this approach. The main issue that arises is the scalability, computation and sparsity of the user-item matrix.

We have used deep neural networks to model the interactions between users and items and this circumvents the issues that arise when implementing CF traditionally.

We implement a Neural Matrix Factorization (NeuMF) [11] model which is a combination of Generalized Matrix Factorization (GMF) [12] model and Multilayer Perceptron model (MLP). This combination results in taking advantage of linearity and non-linearity [13] of the models respectively.

The MLP network is a densely connected network, with four dense hidden layers with Rectified Linear Unit (ReLU) activation function, using binary cross entropy loss function and adam optimizer.

The GMF [12] network is constructed on similar lines, with output layer being densely connected with a single neuron and uses binary cross entropy loss function with adam optimizer. It is a point wise matrix factorization to approximate factorization of a matrix into two matrices.

V. EXPERIMENTATION

A. Ingredient Identification

Accuracy is the number of correct predictions made with respect to all the predictions made. Precision is expressed as the proportion of true positives to all instances classified as positive. Recall is the proportion of true positives to all the instances that are actually positive. F1 sore is the harmonic mean of precision and recall. Mean Average Precision (mAP) is a metric used to evaluate object identifiers. It is the mean of average precision that is calculated for all classes. We have used macro and micro precision (P-C and P-O), macro and micro recall (R-C and R-O), macro and micro accuracy (A-C and A-O), macro and micro F1 measure (F1-C and F1-O) for performance comparison. InceptionV3 [6] shows superior results as seen in table 1.

Approach	mAP	P-C	P-O	R-C	R-O	A-C	A-O	F1-C	F1-O
DenseNet	86.859	82.165	81.146	71.305	71.282	97.176	97.176	74.957	75.884
Inception Resnet	90.467	89.818	88.076	72.477	72.552	97.676	97.676	76.502	79.564
Resnet101	90.552	81.033	78.4504	89.5303	90.145	97.842	97.842	83.767	83.802
InceptionV3	91.104	86.446	85.528	80.53	81.1060	97.966	97.966	82.2801	83.2582

Table 1. Quantitative comparison for Multi Label Classification

B. South Indian Recipe Recommendation

We use Hit Ratio (HR@10) and Normalized Discounted Cumulative Gain (NDCG@10) as the evaluation metrics for the recommendation system. The Hit Ratio (HR@10) measures the number of hits in the top ten recommended results for each user. Normalized Discounted Cumulative Gain (NDCG@10) prioritizes by the hit position logarithmically and performs normalization.

We have implemented item-based and user-based collaborative filtering (ItemCF) and (UserCF) as our baseline models. The results improve by employing GMF [12], MLP and NeuMF [11] approaches. GMF [12] approach yields superior results as seen in table 2.

Approach	HR@10	NDCG@10
UserCF	6.5312	2.8716
ItemCF	7.0439	3.1669
NeuMF	23.72	12.23
MLP	23.86	13.042
GMF	27.005	13.994

Table 2. Quantitative comparison for Recommendation

VI. CONCLUSION

In this work we presented a solution for the task of multi ingredient recognition and subsequent recommendation of South Indian recipes. We achieved this using a combination of deep learning approaches - Multi-label Classification and Recommendation systems.

We have explored many approaches to multi- ingredient recognition on the dataset. We have also developed a personalized South Indian recipe recommendation system. To enable further research on this topic, we have collected multi-ingredient images and South Indian recipes and user ratings.

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REFERENCES

[1] Zhang, Lin et al. "From Market to Dish: Multi-ingredient Image Recognition for Personalized Recipe Recommendation." *2019 IEEE International Conference on Multimedia and Expo (ICME)* (2019): 1252-1257.

[2] Chih-Kuan Yeh, Wei-Chieh Wu, Wei-Jen Ko, and Yu- Chiang Frank Wang, "Learning deep latent space for multilabel classification.," in *Proc. AAAI*, 2017.

[3] Eduardo C. Garrido-Merch´an and Alejandro Albarca-Molina, "Suggesting Cooking Recipes Through Simulation and Bayesian Optimization", arxiv.org, 9 November 2018

[4] Anderson Rocha, Daniel C Hauagge, Jacques Wainer, and Siome Goldenstein, "Automatic fruit and vegetable classification from images," *Computers and Electronics in Agriculture*, vol. 70, no. 1, pp. 96–104, 2010.

[5] Kaiming He and Xiangyu Zhang and Shaoqing Ren and Jian Sun, "Deep Residual Learning for Image Recognition", arXiv:1512.03385, 2015.

[6] Christian Szegedy and Vincent Vanhoucke and Sergey Ioffe and Jonathon Shlens and Zbigniew Wojna, "Rethinking the Inception Architecture for Computer Vision", *arXiv preprint arXiv:1512.00567*, 2015

[7] Nguyen, Long & Lin, Dongyun & Lin, Zhiping & Cao, Jiuwen. (2018). "Deep CNNs for microscopic image classification by exploiting transfer learning and feature concatenation." 1-5. 10.1109/ISCAS.2018.8351550.

[8] Gao Huang and Zhuang Liu and Laurens van der Maaten and Kilian Q. Weinberger, "Densely Connected Convolutional Networks", *arXiv preprint arXiv:1608.06993*, 2016

[9] ratingcollector.net, Website created for collecting ratings from users. URL: www.ratingcollector.net [Last accessed: April 2020]

[10] Badrul Sarwar, George Karypis, Joseph Konstan, and John Riedl, "Item-based collaborative filtering recommendation algorithms," in *Proc. WWW*, 2001.

[11] Xiangnan He and Lizi Liao and Hanwang Zhang and Liqiang Nie and Xia Hu and Tat-Seng Chua, "Neural Collaborative Filtering", *arXiv preprint arXiv:1708.05031*, 2017

[12] Gintare Karolina Dziugaite and Daniel M. Roy, "Neural Network Matrix Factorization", *arXiv preprint arXiv:1511.06443*, 2015

[13] V. Krishna, T. Guo and N. Antulov-Fantulin, "Is Simple Better? Revisiting Non-Linear Matrix Factorization for Learning Incomplete Ratings," 2018 IEEE International Conference on Data Mining Workshops (ICDMW), Singapore, Singapore, 2018, pp. 1289-1293, doi: 10.1109/ICDMW.2018.00183.

18

8.2 Publications

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Paper Title: South Indian Recipe Recommendation from Ingredient Image
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19