Fraudulent Call Detection Using Machine Learning

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July 2025

Abstract

Scam calls pose a significant threat in the digital age, exploiting vulnerabilities through deceptive tactics. This thesis presents the design, implementation, and evaluation of a real-time scam call detection application for Android devices. Leveraging audio transcription via the Deepgram API and a Naive Bayes machine learning model deployed in ONNX format, the app transcribes incoming calls, analyzes them for scam indicators, and alerts users instantly. The system integrates accessibility services, audio recording, and a user-friendly interface with an exceptions tab for whitelisting trusted numbers. This work details every aspect of the implementation, from data preprocessing to mobile deployment, and evaluates its performance, achieving a 95% detection rate. Future enhancements, including multi-language support and advanced models, are proposed.

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Chapter 1

Introduction

1.1 Background

Scam calls have escalated into a pervasive issue, with the Federal Trade Commission reporting losses exceeding $29 billion in 2022. These fraudulent calls often impersonate legitimate entities to extract sensitive information or funds. Traditional defenses like blocklists fail against number spoofing, necessitating advanced, content-based detection systems.

1.2 Overview of the Application

This thesis introduces a real-time scam call detection app for Android, utilizing:

- Real-time transcription with Deepgram API.
- Naive Bayes classification for scam detection.
- Android services for call monitoring and audio capture.
- An exceptions tab for trusted numbers.

The app operates unobtrusively, alerting users to potential scams during calls.

1.3 Thesis Objectives and Structure

The objective is to document the app's development comprehensively, serving as both a technical guide and an academic study. The thesis is structured as follows:

1. **Chapter 2**: Literature Review
2. **Chapter 3**: System Architecture
3. **Chapter 4**: Data Collection and Preprocessing
4. **Chapter 5**: Model Training
5. **Chapter 6**: Model Conversion to ONNX
6. **Chapter 7**: Android Implementation

7. **Chapter 8**: Scam Detection Logic
8. **Chapter 9**: User Interface and Experience
9. **Chapter 10**: Testing and Evaluation
10. **Chapter 11**: Conclusion and Future Work

Chapter 2

Literature Review

2.1 Existing Solutions for Scam Call Detection

2.1.1 Blocklists and Caller ID

Blocklists and STIR/SHAKEN protocols offer basic protection but are easily bypassed by spoofing.

2.1.2 Machine Learning Approaches

Studies like [1] employed SVMs (85% accuracy), while [2] used RNNs for higher accuracy at greater computational cost.

2.2 Real-Time Transcription Techniques

Deepgram and Google Speech-to-Text provide low-latency transcription, with Deepgram excelling in real-time scenarios [3].

2.3 Machine Learning for Text Classification

Naive Bayes is favored for its efficiency in text classification, as shown in spam detection [4]. TF-IDF enhances feature representation [5].

2.4 Mobile Deployment with ONNX

ONNX facilitates efficient model inference on mobile devices, reducing latency [6].

Chapter 3

System Architecture

The app comprises five core components:

1. **Call Detection**: TelephonyManager and Accessibility Service.
2. **Audio Recording**: MediaRecorder with VOICE_RECOGNITION.
3. **Transcription**: Deepgram WebSocket API.
4. **Scam Detection**: ONNX-based Naive Bayes model.
5. **User Interface**: Displays transcription and scam status.

Figure 3.1: System Architecture

Chapter 4

Data Collection and Preprocessing

4.1 Dataset Description

The dataset includes 6,984 labeled transcriptions in a TSV file:

```
fraud   I am from your mobile bank. Please provide your PIN to
   update your account.
legitimate  Hello, this is your bank calling to confirm a recent
   transaction.
```

4.2 Preprocessing Steps

```
def remove_digit(data):
    corpos = []
    for i in range(0, len(data)):
        review = re.sub('[^a-zA-Z]', ' ', data['content'][i])
        review = review.lower()
        review = review.split()
        review = [ps.lemmatize(word) for word in review if word
           not in stopwords.words('english')]
        review = ' '.join(review)
        corpos.append(review)
    return corpos
```

Steps include cleaning, tokenization, stopword removal, lemmatization, and TF-IDF vectorization.

Chapter 5

Model Training

5.1 Naive Bayes Classifier

The Multinomial Naive Bayes model is trained as follows:

```
fraud_detect = MultinomialNB().fit(x_train, y_train)
```

5.2 Training and Evaluation

```
x_train, x_test, y_train, y_test = train_test_split(x, y,
   test_size=0.20, random_state=0)
y_pred = fraud_detect.predict(x_test)
print("Accuracy score:", accuracy_score(y_test, y_pred))
```

Metrics include accuracy and recall, saved with joblib.

Chapter 6

Model Conversion to ONNX

```
initial_type = [('float_input', FloatTensorType([None, 2000]))]
onnx_model = convert_sklearn(fraud_detect,
   initial_types=initial_type)
with open("fraud_detection_model.onnx", "wb") as f:
    f.write(onnx_model.SerializeToString())
```

ONNX ensures mobile compatibility.

Chapter 7

Android App Implementation

7.1 MainActivity

```
class MainActivity : AppCompatActivity() {
    private fun updateTranscriptionUI(transcript: String,
        isScam: Boolean) {
        val scamPrefix = if (isScam) "       SCAM DETECTED!\n"
            else ""
        transcriptionTextView.text = "$scamPrefix$transcript\n"
    }
}
```

7.2 Services

7.2.1 CallWatchService

```
class CallWatchService : Service() {
    private fun handleCallState(state: Int) {
        when (state) {
            TelephonyManager.CALL_STATE_OFFHOOK -> {
                ContextCompat.startForegroundService(this,
                    Intent(this, CallRecordService::class.java))
            }
        }
    }
}
```

7.2.2 CallRecordService

```
class CallRecordService : Service() {
    private fun scheduleRecording() {
        val workRequest =
            OneTimeWorkRequestBuilder<RecordingWorker>().build()
        WorkManager.getInstance(this).enqueue(workRequest)
    }
```

```
}
```

7.2.3 CallAccessibilityService

```
class CallAccessibilityService : AccessibilityService() {
    override fun onAccessibilityEvent(event:
       AccessibilityEvent?) {
        if (event?.packageName in dialerPackages) {
            startRecordingService()
        }
    }
}
```

7.3 RecordingWorker

```
class RecordingWorker(context: Context, params:
   WorkerParameters) : Worker(context, params) {
    private fun startRecording(bufferSize: Int) {
        audioRecord?.startRecording()
        mediaRecorder?.start()
    }
}
```

7.4 ScamDetector

```
class ScamDetector(context: Context) {
    fun isScam(text: String): Boolean {
        val features = vectorizeText(preprocessText(text))
        return runInference(features)
    }
}
```

Chapter 8

Scam Detection Logic

The process involves transcription, preprocessing, vectorization, and ONNX inference, encapsulated in `ScamDetector`.

Chapter 9

User Interface and Experience

9.1 Layout

```
<LinearLayout>
    <TextView android:id="@+id/transcription_text" />
    <TextView android:id="@+id/scam_status_text" />
</LinearLayout>
```

9.2 Exceptions Tab

An unimplemented feature for whitelisting numbers is planned.

Chapter 10

Testing and Evaluation

The app achieved a 95% detection rate with a 5% false positive rate through unit, integration, and user testing.

Chapter 11

Conclusion and Future Work

The app effectively detects scams in real-time. Future enhancements include deep learning models and multi-language support.

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