In the contemporary era dominated by technology, optimizing the potential of mobile sensor resources emerges as a critical necessity. The concept of encapsulating mobile phone sensor data within a black box holds tremendous potential, offering substantial assistance to investigators in resolving crimes. Our thesis introduces an innovative Android application designed as this black box, diligently collecting sensor data for activity classification through machine learning. Initially concentrating on differentiating between suspicious and normal activities, we achieved a remarkable accuracy of 99.7%, reinforcing the credibility of our digital forensics support system. The pioneering modified subspace KNN (msK) algorithm, marked by a unique probability factor, outshines traditional KNN, projecting msK as a tool poised to empower researchers in advancing digital forensics systems with diverse applications.

Transitioning beyond binary classification with msK, our focus shifted to real time data collection using ubiquitous mobile devices. Exploiting their potential for crime scene data capture, reporting, and prompt law enforcement notification, our novel approach incorporates classification methods like Gaussian SVM and KNN, optimized for limited computational power. This system adeptly discerns normal events from abnormal occurrences, achieving 81% accuracy with KNN and 78% with Gaussian SVM. This groundbreaking technique signifies a potential avenue for real-time resolution of enigmatic cases on mobile devices in future forensics.

Beyond algorithmic testing, our thesis introduces the Evidence Collector (EC), an open source mobile app for sensor data collection, developed on the Thunkable platform and freely accessible to the public. In tandem, we propose the IFDenseNet 138 deep neural network algorithm, proficient in analyzing sensor data from the EC app, accurately detecting up to 10 distinct crime scene events. Our primary objective is to assist forensic teams in resolving cases involving deceased victims by harnessing mobile device data.

This data holds transformative potential for reconstructing crime sequences, identifying suspects, and accumulating critical evidence. The development of the EC app and the IFDenseNet-138 algorithm marks a significant leap in forensic investigation, providing forensic teams with powerful tools for addressing complex cases. Our research carries profound implications for the field of forensic science, paving the way for further advancements.

The presented thesis work strategically leverages mobile sensor data for forensic applications, particularly in the realm of criminal activities. The escalating number of criminal incidents, especially in regions like India, underscores the imperative need for advanced technologies to ensure law enforcement. Employing a methodology, integrating deep learning techniques, specifically, combining DenseNet with LSTM networks, our study navigates through standard libraries such as TensorFlow, Keras, Pandas, Numpy, and Matplotlib for classification. The integration of DenseNet with LSTM forms a forensic net, showcasing a novel contribution to the field. The deep learning model, optimized using the Adam optimizer, demonstrates promising accuracy and performance metrics, paving the way for further exploration and application in real world forensic scenarios. Future endeavors could include refining the model, exploring multi-class forensic activities, and addressing security considerations in data handling.

Our thesis also introduces a novel approach to investigating crime scenes using sensor data collected from mobile phones, with a primary focus on identifying crime events through classification methods, specifically Gaussian SVM and KNN. The study demonstrates the potential of utilizing mobile sensor data for crime scene investigation, accurately classifying normal and abnormal events such as assaults with 81% accuracy using KNN and 78% with Gaussian SVM. This method presents a technological solution for solving mysterious cases and emphasizes the importance of real time data collection and analysis using mobile phones to enhance crime prevention and law enforcement efforts.

Throughout the thesis, we diligently curated a dataset for training machine learning models in the context of forensics. This dataset encompasses sensor data recorded during various human activities, focusing on scenarios relevant to forensic analysis. Highlighting the ubiquity of mobile devices with sensors and addressing the challenges of obtaining data for forensic applications, our proposed dataset spans 10 different scenarios and normal scenario, including activities performed by both children and adults, as well as reenactments of potential crime scenes. The inclusion of three repetitions for each scenario enhances the robustness of the dataset, contributing to the advancement of tools for forensic analysis in diverse scenarios.

Delving into the development and application of IFDenseNet-138, an innovative deep neural network algorithm, coupled with the creation of an open source mobile application known as Evidence Collector (EC), our research makes significant strides in forensic investigations. The IFDenseNet-138 algorithm, designed to analyze data collected by EC, demonstrates robust capabilities, achieving an impressive accuracy of 96.32% with high precision and recall scores. This underscores its effectiveness in conducting 10-class classification, enabling the accurate detection of various occurrences at a crime scene.

The primary aim of our research is to contribute to forensic investigations, particularly in cases where the victim is deceased but crucial mobile device data is available. Utilizing this data, forensic teams can reconstruct events leading to the crime, identify suspects, and amass evidence for legal proceedings. Addressing a critical gap in forensic procedures, especially in contexts like India, where a significant number of cases are dismissed annually due to the lack of evidence, our thesis work highlights the potential of mobile device forensics. It leverages the admissibility of mobile phone data as evidence in legal proceedings under Indian laws and emphasizes the importance of adhering to data privacy and protection laws while using mobile phone data as evidence. Our research introduces DenseNet, a type of convolutional neural network designed to improve the performance of traditional CNNs. DenseNet's feature reuse mechanism addresses challenges like vanishing gradients in deep neural networks, enhancing its efficiency. The related research section provides a glimpse into the broader landscape, showcasing the significance of mobile forensics in various domains such as criminal investigations, fraud detection, and cybercrime investigations. It also underscores the role of deep learning techniques in addressing challenges associated with data analysis and interpretation.

In conclusion, our thesis work stands as a significant contribution to the advancement of forensic methodologies, offering a powerful combination of an innovative algorithm (IFDenseNet-138) and a user friendly mobile application (Evidence Collector) for efficient and accurate analysis of sensor data from mobile devices. Our research outlines a robust approach to mobile forensic investigations, emphasizing the detection of suspicious activities using mobile sensor data. The proposed msK algorithm demonstrates promising results, opening avenues for further research in digital forensics and interdisciplinary applications.

We expect the future researcher to develop the msK algorithm further and build a digital forensic system capable of doing bias free decisions. Our approach in the proposed method will give a stepping stone for mobile phone based digital forensics. There could be other cases other than murder, such as robbery, rape, accidents, etc., where digital forensics using mobile phones can be very useful.

5.1 Detection of suspicious activity using mobile sensor data and Modified Subspace K-NN for criminal investigations

- Use of mobile data for detection of crime
- Machine learning technique Modified subspace KNN for classification
- Use of raw sensor data for detecting of abnormal activity
- Accuracy of detection is up to 99.7 %

There are many ways by which the sensor data could have been collected. We have used a simple app designed in Android studio that requires all the permissions from all the sensors. This particular app works as a black box for human activity monitoring similar to a black box installed in airplanes. Because of this data collection app, we could able to stream the data on a UDP stream and receive the same in another program that was written in Matlab. Although our approach was very straightforward the novelty comes into the picture when we talk about modified Ensemble Subspace KNN.

In this particular approach firstly we divided the entire available data into subspaces. These subspaces are randomly selected purposefully as it will allow us to follow the natural actions which are always random. After sub spacing the ensembling and maximum voting based KNN results help us get rid of any biasing present in the output because of the noise. The main modification is the probability based KNN where instead of just saying how many neighbors we also say how close these neighbors are with respect to the current point under observation. This allowed us to jump from accuracy of 98 % to 99.7 %. We also tested the classification with the

RUSBoosted tree(99.5%), subspace discriminant with 83.4%, and Neural network with 99.4%. Because of these reading, we could easily say the proposed algorithm is very efficient with respect to the traditional existing algorithm. We have limited our study to two-class classification but future researchers may explore the opportunity of classifying these mobile data readings into multi-class forensics activity detection. This proposal can be a stepping stone toward digital forensics and we expect these results would improve over time. As the digital data can be updated very easily we need to provide security structures such that no data editing is possible before and after investigation. By this, we can convince the court or judiciary system to accept our proposed mechanism.

The thesis discusses the utilization of mobile sensor data for forensic purposes, aiming to enhance crime investigations, particularly in scenarios where victims cannot provide an account of the events. We employed deep learning techniques, combining traditional LSTM (Long Short Term Memory) and DenseNet for classification. The dataset comprises dramatic reproductions of criminal activities, recorded through mobile sensors, focusing on scenarios like attacks, kidnappings, and pursuits. The model is trained and evaluated on a substantial dataset, providing insights into classification accuracy and relevant metrics.

Advancements in Digital Forensics Systems:

The pioneering Modified Subspace KNN (msK) algorithm, with its unique probability factor, is positioned as a tool poised to empower researchers. Future developments could involve refining and expanding the capabilities of msK, leading to more sophisticated digital forensics systems with diverse applications. The potential for continuous innovation in algorithmic approaches is vast, promising enhanced accuracy and efficiency. Real time Resolution in Mobile Forensics:

The groundbreaking technique of real time data collection using mobile devices, coupled with innovative classification methods like Gaussian SVM and KNN, opens up avenues for prompt resolution of enigmatic cases on mobile devices in future forensics. The continuous evolution of real time processing capabilities, coupled with advancements in algorithmic efficiency, could revolutionize the speed and accuracy of crime scene resolution using mobile data. Expansion of Forensic Applications:

The Evidence Collector (EC) app and the IFDenseNet-138 algorithm present transformative tools for forensic investigations. Future scopes involve expanding the capabilities of EC to cover a broader range of crime scene events and enhancing the adaptability of IFDenseNet-138 to accurately detect a more extensive array of occurrences. This expansion could lead to a comprehensive suite of tools for forensic teams, aiding in diverse and complex cases.

Enhanced Privacy and Security Considerations:

As the field of mobile forensics progresses, addressing security considerations in data handling becomes paramount. Future research could delve into developing robust frameworks that ensure the privacy and protection of sensitive data, aligning with evolving legal and ethical standards. Striking a balance between effective forensic analysis and safeguarding individual privacy will be a critical focus.

Multiclass Forensic Activities and Scenario Variability:

The thesis highlights the potential of deep learning models in forensic analysis. Future work might involve exploring multiclass forensic activities, enabling a more nuanced understanding of crime scene data. Additionally, introducing scenario variability in the training process could contribute to the adaptability of models to a broader range of real world situations, making them more robust and reliable.

Integration with Interdisciplinary Fields:

The study hints at potential interdisciplinary applications, such as adapting the methodology for studying animal behavior in zoology. Future research could explore and foster collaborations between forensic science and other scientific domains, creating synergies that enrich both fields. This integration could lead to novel approaches and insights, pushing the boundaries of forensic investigations.

Global Implementation and Policy Development:

Given the global nature of forensic challenges, there is a future scope for the widespread implementation of advanced mobile forensic technologies. This involves collaboration with law enforcement agencies worldwide and the development of international standards for the use of mobile data as forensic evidence. Future research could actively contribute to the formulation of policies that ensure the ethical and responsible use of technological advancements in forensic practices.

Continuous Evolution of Deep Learning Models:

The integration of DenseNet with LSTM in forensic analysis is a novel contribution. Future explorations might involve continuous refinement of deep learning models, experimenting with different architectures, and leveraging emerging technologies to improve the efficiency and accuracy of these models. Keeping pace with advancements in the deep learning landscape ensures that forensic methodologies remain at the forefront of technological innovation.

Public Engagement and Education:

The open source nature of the Evidence Collector app opens avenues for public engagement. Future scopes include initiatives for public education on the role of mobile devices in forensic investigations. Promoting awareness and understanding among the general public about the responsible use of technology in crime resolution fosters a collaborative environment between forensic teams and the community.

Ethical Considerations in Forensic Research:

With the increasing reliance on advanced technologies, future research could delve into the ethical implications of mobile forensic practices. This involves critically examining the ethical considerations surrounding the use of deep learning algorithms, ensuring transparency, fairness, and accountability in their deployment. Incorporating ethical frameworks into forensic methodologies becomes essential for maintaining public trust. In essence, the future scopes outlined above not only underscore the continuous evolution of mobile forensic technologies but also emphasize the responsibility of researchers and practitioners to navigate these advancements ethically and with a commitment to societal wellbeing. The transformative potential of these technologies lies not just in their technical prowess but in their conscientious and responsible application for the greater good.

The msK, Gaussian SVM, KNN, and IFDensenet models underwent testing for both binary and, subsequently, multiclass classification. Notably, binary classification exhibited highly accurate results, aligning with its primary objective of detecting suspicious activities rather than normal ones. The primary challenge encountered in this thesis pertained to multiclass classification. Effectively categorizing sensor data for a single event into multiple potential outcomes posed significant difficulty. In such instances, the case with the highest activity probability was selected as the primary event for classification and identification.

Strengths of the proposed system:

- Rich data source: Mobile phones are equipped with a multitude of sensors that capture various aspects of the user's activity and environment, including GPS location, accelerometer readings, gyroscope data, magnetometer readings, light sensor data, and even microphone audio (with proper permissions). This rich tapestry of data can provide invaluable insights into a user's movements, actions, and even emotional state.
- Timestamped data: The timestamped nature of the data collected by the app is crucial for forensic analysis. It allows investigators to reconstruct timelines of events with high accuracy, pinpoint specific locations, and correlate sensor data with other forms of evidence.
- Black box concept: The black box approach ensures data integrity and tamper-proof collection, which is essential for maintaining the chain of custody in legal proceedings.

Challenges to consider for the proposed method:

- Privacy concerns: Collecting and storing such comprehensive sensor data raises privacy concerns. It's crucial to implement robust user consent mechanisms, data anonymization techniques, and clear data retention policies to address these concerns.
- Data interpretation: Analyzing and interpreting the vast amount of sensor data can be challenging. Developing algorithms and machine learning models to extract meaningful insights from the data will be crucial for its effective use in forensics.
- Legal admissibility: The legal admissibility of mobile phone sensor data as evidence is still evolving. Collaborating with legal experts to ensure the system's compliance with relevant laws and regulations will be important.

There are some considerations before one can plan to deploy the proposed model:

1. **Data Collection**: Ensure that the data collected from various sensors (like GPS, accelerometer, gyroscope, etc.) is comprehensive and accurately timestamped. This will be crucial for the analysis.
2. **Privacy Concerns**: Be mindful of privacy laws and regulations. User consent is paramount when collecting and using such data.
3. **Data Analysis**: Depending on the nature of the forensic cases, different types of data analysis might be needed. Proposed machine learning algorithms could be useful in identifying patterns or anomalies in the data.
4. **Testing**: Rigorous testing will be necessary to ensure the accuracy and reliability of the system. One must consider creating test cases that mimic real world scenarios.
5. **User Interface**: Since the app acts like a black box, it's important to design an intuitive user interface. This will help users understand what data is being collected and why.

In summary, our document presents a holistic and transformative approach to leveraging mobile sensor data for forensic purposes. We introduce cutting edge technologies, including the IFDenseNet-138 algorithm and the Evidence Collector app, both poised to revolutionize forensic investigations. From real time data collection to innovative classification methods and the development of a comprehensive dataset, our research covers critical aspects of mobile forensics. This thesis work not only contributes to advancing forensic methodologies but also holds profound implications for the effective resolution of criminal cases and the enhancement of law enforcement efforts.