A WhatsApp-Based Application for Automatic Data Collection and Crime Monitoring in Belo Horizonte

Gustavo Silva da Fonseca
Universidade Federal de Ouro Preto
gustavo.fonseca@aluno.ufop.edu.br

Guilherme S. Patrício
Universidade Federal de Ouro Preto
guilherme.patricio@aluno.ufop.edu.br

Carlos H. G. Ferreira
Universidade Federal de Ouro Preto
chgferreira@ufop.edu.br

Alexandre M. de Sousa
Universidade Federal de Ouro Preto
alexandre.sousa@ufop.edu.br

ABSTRACT

This work presents the development of a crime monitoring system for Belo Horizonte based on the automatic collection of messages from public WhatsApp groups. The system adopts a modular and scalable architecture, integrating services for filtering, structuring and storing data in a hierarchical database that supports queries by region, neighborhood and time period. Crimes are identified in two steps: (1) an initial filter detects potential crime-related messages using a predefined dictionary of keywords, and (2) a Machine Learning model classifies the messages with higher accuracy. This automated pipeline ensures continuous data processing without manual intervention and provides up-to-date geographic information on crimes. The proposed framework demonstrates the feasibility of using instant messaging platforms for real-time crime monitoring and offers scalability and adaptability for application in other cities and related data monitoring contexts.

KEYWORDS

Architecture, NestJS, MongoDB, Firestore, Integration, Automatic Data Collection, WhatsApp, Crime Monitoring.

1 INTRODUCTION

According to the violence map published by the *Instituto de Pesquisa Econômica Aplicada (IPEA)*, violence is one of the biggest public policy problems in Brazil[1]. Feelings of insecurity and fear are present in the daily lives of many Brazilians, especially in large urban centers. The traces of violence are manifold and leave scars both in the lives of those affected and in society as a whole [15]. As a result, more and more people are seeking entertainment at home and avoiding public places, especially at night. Therefore, finding a safe place to live is becoming increasingly important, which explains the growing demand for gated communities. In this way, violence influences the structure, composition and spatial organization of a city [9], a phenomenon entitled *architecture of fear* [5]. There is also evidence that crime is a key factor in the devaluation of real estate, which has a direct impact on the economy of cities [15].

[1] https://www.ipea.gov.br/atlasviolencia/

In: XXIV Workshop de Ferramentas e Aplicações (WFA 2025). Anais Estendidos do XXXI Simpósio Brasileiro de Sistemas Multimídia e Web (WFA'2025). Rio de Janeiro/RJ, Brasil. Porto Alegre: Brazilian Computer Society, 2025.

ISSN 2596-1683

Given these social and economic impacts, addressing urban violence requires not only traditional public policies but also innovative approaches capable of anticipating and monitoring criminal activity. In this context, rising crime rates and the demand for effective surveillance solutions highlight the importance of advanced technologies [3]. Recent studies indicate that the use of social media and other open sources can be a powerful tool for monitoring criminal activity [2, 6–8]. However, despite these advances, most existing initiatives remain limited to retrospective analyses or specific case studies. Few works provide **practical systems** that automatically extract, classify, and update crime-related information on a scheduled basis, especially from instant messaging platforms such as WhatsApp. This gap is particularly relevant in medium-sized Brazilian cities such as Belo Horizonte, where reliable and timely crime data are scarce.

This work addresses this gap by developing an integrated system that combines Web scraping, Natural Language Processing (NLP) and Machine Learning (ML) techniques to automatically collect, classify and map crime-related messages from WhatsApp groups and news sites. The system feeds an updated database that supports a mobile application for real-time crime visualization. In practice, the application allows users and public safety agencies to quickly identify risk areas, track incidents, and access timely information for decision-making. Our objective is to provide an agile and efficient solution that not only overcomes the limitations of traditional surveillance methods, but also demonstrates how digital platforms such as WhatsApp can be systematically leveraged for public safety. The proposed tool offers a concrete contribution at the intersection of research and application: by integrating automated data extraction, information classification, and real-time visualization, it delivers a usable resource for monitoring crime dynamics in Belo Horizonte [6].

The main contribution of this work is the development of an intelligent crime monitoring and mapping system that utilizes data from instant messaging applications to detect, classify, and disseminate information about security incidents. The use of these technologies in the context of Belo Horizonte is particularly relevant given the growing concern for public safety and the need to improve crime prevention and control strategies. Furthermore, although this study focuses on a specific city, the proposed approach can serve as a reference for other urban contexts, demonstrating how digital platforms and ML-based analysis can be leveraged to build practical surveillance tools adaptable to different regions and scenarios.

2 BACKGROUND AND RELATED WORK

Online social media monitoring has become an indispensable tool to detect and analyze real-world events such as humanitarian crises, natural disasters and crimes [11]. This has attracted the attention of researchers and authorities in areas including public safety, crisis management and urban policy [10]. Recent studies show that posts and interactions on social media can be transformed into valuable sources of information for decision-making in emergency situations [14]. Instant messaging apps (e.g., WhatsApp and Telegram) also play an important role in disseminating real-world information and are often primary sources of real-time reporting . Unlike open social media, these apps enable direct communication via private messages or groups, which poses challenges for collecting and analyzing information, since the content is not publicly indexed and many messages may be inaccurate or even fake [13].

Research indicates that combining multiple data sources, including open social media, verified news, and information from private groups, can increase the reliability of event detection [11, 19]. This integrated approach mitigates risks associated with disinformation and improves the accuracy of analysis. Consequently, the study and implementation of systems capable of collecting and processing information from instant messaging apps is becoming increasingly important for critical event monitoring and public safety.

Several works address methods for extracting and analyzing data related to public safety. Aghababaei and Makrehchi [1] propose a model for predicting crime trends based on data mining of tweets posted in the Chicago region and additional data on criminality rates. The model is intended to support decision support systems, that enable targeted research to identify the causes of crime, and help law enforcement and police decision makers. However, they used lagged data. Vomfell et al. [20] proposed predictive models that integrate data from social media, public places, and cab rides in New York, USA. The analysis, which combined machine learning and spatial econometrics techniques, showed that using multiple data sources can significantly improve crime prediction, although the short analysis period was a limitation. Similarly, Williams et al. [21] investigated the possibilities of using big data to predict crime in London, England, using online data from social media. Following the Broken Windows Theory, they found that tweets indicating social disorder correlated with crime, particularly in low-crime areas. The study showed an innovative approach to analyzing tweets, but also pointed to the need for better data visualization. In addition, Ristea et al. [18] investigated the relationship between sporting events, social media, and crime, particularly on ice hockey game days in Vancouver, Canada. The research identified an increase in crime on game days with a spatial analysis that revealed the most affected areas. This approach provided valuable insights into how certain events can influence crime in different regions. Nevertheless, Ferreira et al. [7] proposes a model for the automatic extraction of public safety statistics from informal sources as X platform. The authors propose a methodology that relies mainly on knowledge discovery with text mining algorithms and an automated pipeline. However, the approach only focuses on the city of Rio de Janeiro. In turn, Nascimento et al. [12] explores the use of web scraping techniques to collect public safety data from unstructured sources (e.g., websites and blogs which discuss public safety issues) and proposes an efficient extraction approach. Despite its efficiency, the method is limited to the creation of a textual corpus from websites requires constant adjustments to remain functional when site structures change. Finally, Prathap and Ramesha [17] highlights the importance of sentiment analysis to analyze the crime perceptions on online social media for understanding security trends using geographical location. However, it does not directly address an continuous automated data collection.

In contrast to previous approaches, which usually rely on open platforms (such as X, forums or public websites), the system developed in this work automatically collects messages on a scheduled basis, even from environments without public APIs, such as WhatsApp. This represents a significant advance, as it enables continuous and decentralized monitoring of crime reports, improves database updates and significantly reduces the need for manual intervention.

3 METHODOLOGY AND DEVELOPMENT

The methodology used in this work aims to develop a system for monitoring crime in Belo Horizonte using data from public WhatsApp groups. The process is divided into several phases focusing on the identification and classification of messages related to crimes.

The tools and technologies used in the development of the application proposed in this work and their respective purposes are described below: (1) Git[2]: is used for documenting the changes to the source code of the application; (2) GitHub[3]: for version control and hosting of the project's source code; (3) MongoDB[4]: for storing messages from groups and other files created by filtering, classifying and analyzing; (4) *Python* language with the `scikit-learn`[5] and `spaCy`[6] libraries, used in text data processing and the development of ML classification models; (5) Node.js[7]: as the execution environment for the development of the system backend; (6) NestJS[8]: used as a framework for building the API and enabling a modular and scalable structure; (7) Cloud Firestore[9]: to store crime data that feeds the information displayed in the application; (8) *Android Studio*[10], an integrated development environment for Android apps; (9) *Flutter*[11]: for the development of Android app interfaces; (10) *Google Maps API*[12]: for adding maps and geolocation information.

An in-depth investigation of potential data sources that could provide relevant information without manual intervention was carried out. Among the alternatives investigated, public Telegram groups, news websites and the X API were considered. However, all of these options presented technical, economic or structural limitations that made their use unfeasible in the context of this project. Given these constraints, WhatsApp was chosen as the primary data source. This choice was motivated by the fact that WhatsApp is one of the most widely used communication tools in many Brazilian contexts, including for sharing real-time events such as crimes, accidents and risky situations. Recent studies, such as Pires et al. [16], show that WhatsApp is an important channel for monitoring real-world events, especially in communities that use public groups for alerts and social mobilization. In addition, the use of WhatsApp groups offers considerable technical advantages: the data collected are usually structured in short, direct text messages

[2] https://git-scm.com [3] https://docs.github.com [4] https://www.mongodb.com
[5] https://scikit-learn.org [6] https://spacy.io [7] https://nodejs.org
[8] https://docs.nestjs.com [9] https://firebase.google.com/docs/firestore
[10] https://developer.android.com/studio [11] https://flutter.dev
[12] https://developers.google.com/maps

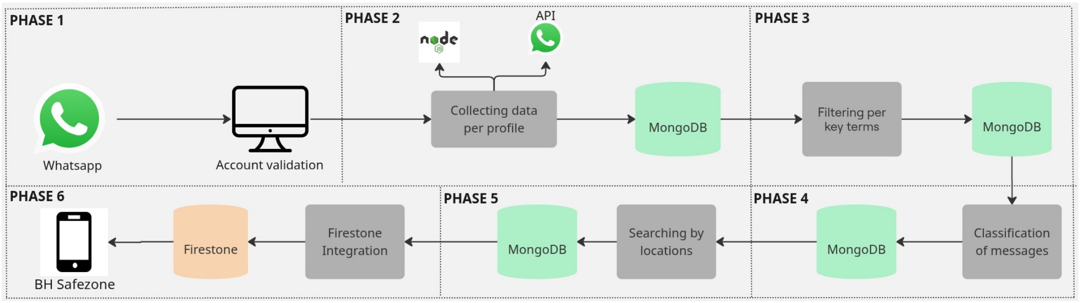


Figure 1: Design system architecture for the crime monitoring and visualization in Belo Horizonte.

often accompanied by location information, images or testimonies. The implementation of the collection system on this platform represents a significant step forward compared to other work in this area, most of which still relies on open sources or already available data and does not explore the potential of automated and continuous collection in closed environments such as WhatsApp.

The system architecture was designed to work autonomously, without the need for manual intervention. Figure 1 shows the architecture, divided into six phases described as follows. **Phase 1:** initially, Google and Platform X were used to search for news groups about the city of Belo Horizonte, focusing on groups that could provide information about crime in the city. The groups *BHAZap*[13], *Por Dentro de Minas*[14], *DeFato*[15], *Agito Mais*[16], *JCO*[17] and *JCA*[18] were identified. To ensure the reliability of the information, the criterion of selecting only groups in which the administrator is solely responsible for sharing messages was adopted, avoiding the dissemination of irrelevant information. In addition, these groups have websites linked to recognized media, which guarantees the credibility of the content shared. **Phase 2:** WhatsApp messages are collected using the `whatsapp-web.js` library[19], which enables the automatic extraction of messages shared in public groups. Each group has a unique identifier (ID) that differs depending on the user. Messages can be retrieved individually for each group, allowing the system to segment the data in a structured and efficient way. This service runs automatically each day at a scheduled time, ensuring continuous collection without manual intervention. **Phase 3:** a dictionary of crime-related terms (e.g., "*robber*", "*theft*", "*murder*") is used as a filtering mechanism. This step ensures that only messages containing potential crime-related terms proceed to subsequent stages, thereby reducing noise. The terms are grouped in categories[20] such as: *robbery, theft, assault, femicide, rape, extortion, kidnapping, murder, drug trafficking, attempted murder, vandalism* and *fire*. The system is designed to handle large volumes of data, and new terms or expressions can be easily incorporated to keep the dictionary updated. **Phase 4:** in this phase, filtered messages are subjected to ML-based binary classification ("crime" vs. "non-crime"). The Support Vector Machine (SVM) algorithm was chosen. To ensure model robustness, cross-validation was performed and the dataset was divided into three subsets: training, validation, and testing. Class imbalance was addressed by *downsampling* [4]. Once the model was evaluated and validated, it was integrated into the system, which performs regular automatic updates to keep classifications current. **Phase 5:** after classification, the system identifies the location of the incident. This localization process is divided into three steps: (1) identification of places/entities in the text, using `spaCy`[21] for Named Entity Recognition (NER) to extract names of streets, neighborhoods or regions; (2) verification of external links: if a message contains a link, Web scraping is applied to extract the full text and identify locations using NER; (3) identification of neighborhoods and regions: the Belo Horizonte City Hall Geocoder API[22] is used to obtain geographic coordinates of the identified locations, complemented by neighborhood and zone dictionaries when API queries are restricted. **Phase 6:** finally, Firestore integration stores and organizes the data collected from WhatsApp messages. Crimes are recorded hierarchically and organized into collections separated by region and general grouping, enabling both specific and global queries. Within each collection, crimes are stored as documents, each representing a type of crime and containing the number of recorded incidents.

In addition to categorization by crime type, records are also organized by time period, with subdivisions of regions into neighborhoods, providing greater granularity for analysis. The Android application interface was implemented using the *FL Chart* library in *Flutter*, with the goal of providing users with accessible information about crime by region. Functional requirements include visualization of crime data on a map of Belo Horizonte via the *Google Maps API*. Users can view the city map, select areas to obtain detailed information on the type and number of crimes, and records by period and by neighborhood. Another feature is the ability to report crimes anonymously, which are then displayed in the application.

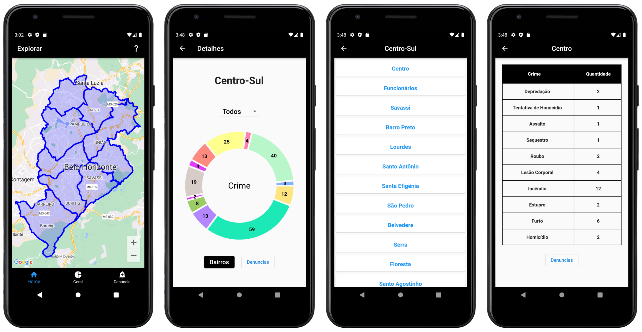
4 RESULTS

This work has a freeware license and its app can be downloaded from the link <https://shre.ink/SBuP> and easily installed on mobile devices with Android platform. It also provides a perspective for societal use that is accessible to the public and represents an advance in the monitoring and prevention of crime in urban areas, as its use will help residents and visitors to the city of Belo Horizonte to avoid high-risk areas. For more information on using the app to monitor and visualize geographic crime information, see a brief demonstration of the app's features at <https://shre.ink/SBhq>.

The system has collected a total of 4,313 messages from the monitored groups, of which 687 were classified as crimes. The classifier achieved an accuracy of 0.96 and an F1-score of 0.97 after training and testing. It has been deployed in the system architecture and is

[13] https://bhaz.com.br [14] https://pordentrodeminas.com.br
[15] https://defatoonline.com.br [16] https://agitomais.com.br
[17] https://www.jornaldacidadeonline.com.br [18] https://comunidadeemacao.com.br
[19] https://wwebjs.dev [20] The terms within categories were omitted to save space and were based on Secretária de Estado de Justiça e Segurança Pública (SEJUSP): www.seguranca.mg.gov.br.

[21] https://spacy.io/ [22] https://geocoder.pbh.gov.br/geocoder/



(a) Home. **(b) Region.** **(c) NBHD list.** **(d) NBHD table.**

Figure 2: Visualization interfaces of app.

in production, enabling the automatic and continuous classification of WhatsApp messages without manual intervention. Of the 687 crime-related messages, 379 originated from an unknown region. Within this group, 146 were from outside the Belo Horizonte metropolitan region, while 233 were from Belo Horizonte without a specified location. In contrast, 308 messages indicated a specific location within Belo Horizonte, with 120 pointing to specific neighborhoods and regions, while 188 were within the metropolitan region but did not name a specific location.

Figure 2a illustrates the main interface of the application, displaying a map of Belo Horizonte with polygons defined by geographical coordinates that highlight different areas. These polygons act as interactive buttons: when selected, they open a page with information about local crimes in the corresponding area. Crime types and frequencies for neighborhoods and regions are displayed using donut charts, which show crime categories and the number of incidents. Users can view this information by region (Figure 2b) or select month and year from a drop-down menu to analyze temporal trends. By clicking on a section of the donut chart, that crime type is highlighted and its details are displayed. Users can view detailed information by selecting a neighborhood (NBHD) from a list (Figure 2c), that provides a table of incidents as shown in Figure 2d.

5 DISCUSSIONS AND FUTURE DIRECTIONS

This work advances the field of public safety by demonstrating the potential of digital platforms for crime monitoring and real-time data visualization. The main contribution is the development of an automated system that collects, processes, and classifies WhatsApp group messages to identify crime-related incidents and generate geographic information that is easily accessible to the public. The system is not only a technical proof of concept but also a practical tool, designed to support both citizens and public authorities in accessing timely and structured crime data. To the best of our knowledge, no other application dedicated exclusively to monitoring crime in Belo Horizonte based on social networks or instant messengers such as WhatsApp has been identified.

Despite its contributions, the system has limitations. Its reliance on the `whatsapp-web.js` library, which simulates WhatsApp's web interface, creates a potential vulnerability as changes to the platform or restrictions by WhatsApp may affect continuity, requiring frequent maintenance or alternative solutions. Another limitation concerns the scope of data sources. Currently, information is restricted to WhatsApp groups, which may not capture all relevant incidents. Expanding data integration to WhatsApp channels, Telegram, and government databases could provide a more comprehensive and reliable view of crime dynamics.

Looking ahead, future work should focus on extending and strengthening the system as a tool for continuous monitoring. Key directions include: (*i*) strategies for automatic updating of the classification model as the database grows, possibly incorporating Large Language Models APIs; (*ii*) architectural improvements through microservices and message queues to ensure scalability and robustness; and (*iii*) extending the system's applicability to other cities and contexts, demonstrating its potential as a transferable solution for automatic monitoring of urban violence.

REFERENCES

[1] Somayyeh Aghababaei and Masoud Makrehchi. 2018. Mining Twitter data for crime trend prediction. *Intelligent Data Analysis* 22, 1 (2018), 117–141.
[2] L. G. A. Alves, H. V. Ribeiro, and F. A. Rodrigues. 2020. Crime prediction through urban metrics and statistical learning. *Physica A: Statistical Mechanics and its Applications* 540 (2020), 123–138.
[3] Cristian Aquino. 2021. Como a tecnologia pode ajudar a segurança pública nas cidades. https://www.moneytimes.com.br/cristian-aquino-como-a-tecnologia-pode-ajudar-a-seguranca-publica-nas-cidades/. Accessed: 2025-04-28.
[4] Andriy Burkov. 2019. *The hundred-page machine learning book*. Vol. 1. Andriy Burkov Quebec City, QC, Canada.
[5] Teresa Pires do Rio Caldeira. 2000. *Cidade de muros: crime, segregação e cidadania em São Paulo*. Editora 34, São Paulo, Brasil.
[6] X. Chen and Y. Liu. 2023. Crime hotspot prediction using social media data and machine learning: A case study in New York City. *Computers, Environment and Urban Systems* 99 (2023), 102–115.
[7] F. Ferreira, J. Duarte, and W. Ugulino. 2022. Automated Statistics Extraction of Public Security Events Reported Through Microtexts on Social Networks. In *Proc. of the XVIII SBSI* (Curitiba, Brazil) *(SBSI '22)*. ACM, New York, NY, USA.
[8] S. Kumar and S. K. Singh. 2022. Real-time crime detection using social media analytics: A deep learning approach. *Journal of Big Data* 9, 1 (2022), 1–20.
[9] P. Lira. 2017. *Geografia do crime e arquitetura do medo: uma análise dialética da criminalidade violenta e das instâncias urbanas*. Letra Capital Editora LTDA, Vitória, ES, Brasil.
[10] M. S. Md Suhaimin, M. H. A. Hijazi, E. G. Moung, P. N. E. Nohuddin, S. Chua, and F. Coenen. 2023. Social media sentiment analysis and opinion mining in public security: Taxonomy, trend analysis, issues and future directions. *Journal of King Saud University - Computer and Information Sciences* 35, 9 (2023), 101776.
[11] M. S. Mredula, N. Dey, Md. S. Rahman, I. Mahmud, and Y.-Z. Cho. 2022. A Review on the Trends in Event Detection by Analyzing Social Media Platforms' Data. *Sensors* 12 (2022).
[12] M. Nascimento, V. Silva, G. Souza, K. Lima, E. Araújo, E. Souza, J. Turet, and V. Carvalho. 2025. Extração de Notícias sobre Segurança Pública para Desenvolvimento de Corpora em português: uma análise preliminar em cidades do nordeste brasileiro. In *Anais do VI WICS* (Maceió/AL). SBC, Porto Alegre, RS, Brasil.
[13] Gabriel Peres Nobre, Carlos HG Ferreira, and Jussara M Almeida. 2022. A hierarchical network-oriented analysis of user participation in misinformation spread on WhatsApp. *Information Processing & Management* 59, 1 (2022), 102757.
[14] R.I. Ogie, S. James, A. Moore, T. Dilworth, M. Amirghasemi, and J. Whittaker. 2022. Social media use in disaster recovery: A systematic literature review. *International Journal of Disaster Risk Reduction* 70 (2022), 102783.
[15] L. A. R. Paixão. 2009. O impacto da violência no preço dos imóveis comerciais de Belo Horizonte: uma abordagem hedônica. *Economia Aplicada* 13 (2009), 125–152.
[16] B. A. Pires, L. F. Machado, A. A. Lacerda, and W. de Oliveira. 2023. A importância de grupos de WhatsApp na detecção de eventos do mundo real. In *Anais do Simpósio Brasileiro de Sistemas Colaborativos (SBSC)*. SBC, Porto Alegre.
[17] B. R. Prathap and K. Ramesha. 2018. Twitter Sentiment for Analysing Different Types of Crimes. In *2018 IC3IoT*.
[18] Alina Ristea, Martin A Andresen, and Michael Leitner. 2018. Using tweets to understand changes in the spatial crime distribution for hockey events in Vancouver. *The Canadian Geographer* 62, 3 (2018), 338–351.
[19] O. R Venâncio, G. H. S. Gonçalves, C. H. G. Ferreira, and A. P. C. da Silva. 2024. Evidências de disseminação de conteúdo no Telegram durante o ataque aos órgãos públicos brasileiros em 2023. In *WebMedia*. SBC, 385–389.
[20] Lara Vomfell, Wolfgang Karl Hardle, and Stefan Lessmann. 2018. Improving crime count forecasts using Twitter and taxi data. *Decision Support Systems* 113 (2018), 73–85.
[21] Matthew L Williams, Pete Burnap, and Luke Sloan. 2017. Crime sensing with big data: The affordances and limitations of using open-source communications to estimate crime patterns. *The British Journal of Criminology* 57, 2 (2017), 320–340.