Violations: Improving Egyptian Environmental Services Via AI technology Violation Monitoring System

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Abstract:

A big challenge facing Egypt and other developing countries, it is the spread and release of the phenomenon of environmental violations. They are one of the reasons for the backwardness, disruption and the lateness of nations. Bـَsides, a lot of people are suffering from respiratory diseases. Due to the difficulty of communicating and reporting it, and more importantly following-up of solving such violations, it is difficult to overcoming such phenomenon.

More than one computer application has been developed, namely; ***violations****,* ***Kollna Amn*** and ***Public Eye*** applications**,** *to overcome such phenomenon, which allows reporting the violation to the responsible governmental agency to resolve it. The reporting, and the following-up of such violations is done traditionally by the reporter human eye, which is an impractical way and is difficult to be achieved by citizen, besides it is time consuming and not accurate. Such applications use chat bot in its basic state to direct the user to correctly use the applications. The above applications are not efficient enough to solve the problem. That is why there is a big need to use today's technology to facilitate communication, reporting, and follow-up violations recovery and to speed up such process. .*

This paper introduces a proposed system, using AI technology, to implement an optimized way for easily, accurately, simply, rapidly, and efficiently communicate, report any violation, to the responsible governmental agency, and follow-up resolving it.

This system is based on the fact that violation can be efficiently communicated and followed-up using image processing technology without the reporter intervention as the case in the stated above applications, while it is done precisely, fast, rapidly, and easily.

In the first section, the introduction, the existing applications have been briefly described. In the second section the literature review has been introduced covering the artificial intelligence, AI, the Chabot, and the image processing. In the third section the problem definition is stated including the problem statement and the problem formulation. In the fourth section the proposed system has been described covering system stockholders, basic functionalities (system use cases), proposed system description, system business requirements, and system SW architecture. In the fifth section the proposed system measurements and results has been analyzed. Finally, the conclusion is stated.

Key words: Violation application, AI, Image Processing, Chatbot.

I. Introduction

We all suffer, daily, from environmental violations. It represents one of the manifestations of the backwardness of nations. In addition, it disrupts the progress, destroys the public taste of citizens, spreads frustration atmosphere and vanish the citizen' sense of welfare. In addition, it leads to environmental degradation which is costly to individuals, to societies, and to the environment.

Therefore, the necessary measures must be taken to eliminate it. According to figures published in World Bank records **[1]**, air pollution has been a problem for Egyptians for decades, particularly in large cities such as Cairo. In Greater Cairo, levels of the fine particulate matter PM10 and PM2.5, that pose the greatest risk to people's health are several times higher than the levels the World Health Organization (WHO) recommends. Egypt's Ministry of Health says that in the country as a whole, as many as two million people a year seek medical treatment for respiratory problems related to poor air quality. Other forms of violations are encountered in this effort, as well.

Such violations should be reported to the responsible governmental agency, **RGA**, to recover. Due to some reasons, the reporting of such violations is not efficient enough. This leads to the recurrence of such violations, which in turn increases the spread of negative manifestations in society. Actually, some electronic applications have been developed to help in reporting process.

One of the applications which has been developed, referred to as ***Violations***, allows reporting the violations to the RGA to resolve such weakness. The application covers the following violations' categories: garbage, humanitarian cases (street children, lost ones), wastewater violation, building and estate violations, accidents, traffic violations, and road violations (pots, obstacles). The objectives of the application are to allow faster communication between the reporter (the citizen who report the violation) and the RGA and following-up overcoming such violation to minimize bad effects as possible. In the Violation application, the mobile application, allows the **reporter** to capture the violation, then registering related data including: the category of violation, the status, the address, the location on the map, and the description. Then send such violation by e-mail to RGA. In this application, the RGA are classified into three levels for violation recovery. All detected violations are reported by e-mail to the first level, while second and third levels for following-up the violation recovery. Whenever the RGA recovers the violation, he responds with an e-mail to the **reporter**.

Other application, referred to as ***Public Eye*,** which takes, a photo or video of the erring situation along with its identifications, and post the violation on Public Eye site. Within 48 hours someone will get in touch with the site for that violation. This application can post a complaint on a variety of violation classes, namely; no parking, one way, no entry, parking on footpath, riding on footpath, riding without a helmet, not wearing seat belt, triple riding, using mobile phone, violation lane discipline, wrong parking, and others. The advantages can be: live connections, and normal GPS supported. While the disadvantages can be: the in-ability to send recordings, speed shots, or live connection, since some violations happening may need speedier action [**2**].

A third application, referred to as ***Kollna Amn***, which is an android application that helps reduce irregularities while at the same time helping to solve the problem instead of resorting to any governmental side. It is most appropriate for solving the problems in case of small amount of violations in a time. But it will be impractical in case of big amount of such violations [**3**].

In this paper, we introduce an improvement to such applications using AI technology, in specific: the chatbot and image processing technology, aiming to automate the process of violations reporting and recovery follow-up.

II. Literature Review

A. Introduction to Artificial Intelligence, AI

Artificial Intelligence, AI, is the ability of a computer program to learn and think. AI makes it possible for machines to learn from experience, adjust to new inputs and perform human-like tasks. AI deals with large amounts of data that are subjected to fast and iterative processing, together with smart algorithms that allow the system to learn from patterns within the data. This way, the system would be able to deliver accurate or close to accurate outputs. Nowadays, AI becomes one of the most important and critical technologies. Bots, image processing, voice recognition, Robotics, etc. are all fueled by AI. At the current growth rate, it is going to be a driving force for a very long time in the future as well [**4**]

The major subfields under AI can be machine learning, deep learning **[5] [6],** natural language processing **[7] [8]**, computer vision **[9] [10]**, neural networks, and cognitive computing **[11]**.

B. Introduction to Chabot

Artificial Intelligence (AI) increasingly integrates our daily lives with the creation and analysis of intelligent software and hardware, called intelligent agents. Intelligent agents can do a variety of tasks ranging from labor work to sophisticated operations. A chatbot is a typical example of an AI system and one of the most elementary and widespread examples of intelligent Human-Computer Interaction (HCI). It is a computer program, which responds like a smart entity when conversed with through text or voice and understands one or more human languages by Natural Language Processing (NLP). Chatbots are also known as smart bots, interactive agents, digital assistants, or artificial conversation entities. Chatbots can mimic human conversation and entertain **reporters**, but they are not built only for this. They are useful in applications such as education, information retrieval, business, and e-commerce [**12**] [**13**].

A chatbot is a computer software that uses Artificial Intelligance (AI) and Natural Language processing (NLP) to understand customer questions and automate responses to them, simulating human conversation [**14**][**15**][**16**][**17**][**18**]. Chatbots can be classified as voice bots, hybrid chatbots, social messaging chatbots, menu-based chatbots, skills chatbots, keyword-based chatbots, rules-based chatbots, AI-powered contextual chatbots, support chatbots, transactional bots, and no code or low code chatbots [**19**][**20**][**21**].

The design and development of a chatbot involve a variety of techniques. The first step in designing any system is to divide it into constituent parts according to a standard so that a modular development approach can be followed. In **Figure (1)**, a general chatbot architecture is introduced [**22**].

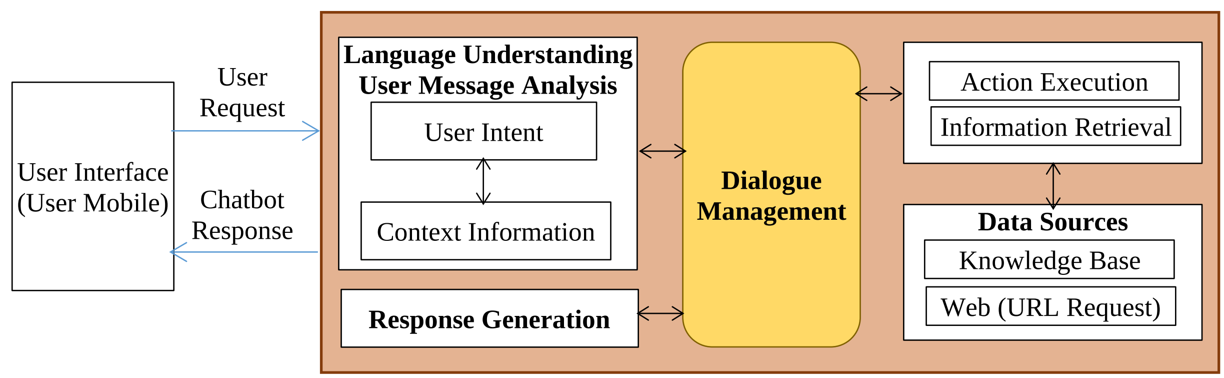


Figure (1): General Chatbot Architecture

C. Introduction to image processing

Sometimes images lack contrast and brightness because of the limitations of imaging sub systems and illumination conditions while capturing image. Images may have different types of noise. One of the phases is the ***image enhancing***. In image enhancement, the goal is to accentuate certain image features for subsequent analysis or for image display. The enhancement process itself does not increase the inherent information content in the data. It simply emphasizes certain specified image characteristics. Enhancement algorithms are generally interactive and application dependent [**23**]. ***Image segmentation*** is the process that subdivides an image into its constituent parts or objects. The feature extraction techniques are developed to extract features in synthetic aperture radar images. This technique extracts high-level features needed to perform classification of targets. ***Classification*** is the labeling of a pixel or a group of pixels based on its grey value [**19**], [**20**]. Classification is one of the most often used methods of information extraction, ***Feature Extraction***. Most of the information extraction techniques rely on analysis of the spectral reflectance properties of such imagery and employ special algorithms designed to perform various types of 'spectral analysis'. The process of multispectral classification can be performed using either of the two methods: **Supervised** or **Unsupervised** [**24**].

Image segmentation is an important stage of digital image processing, which is the process of segmenting the image into interconnected and homogeneous regions according to a specific criterion such as color. The union of these regions should result in a reconstruction of the original image. **Feature extraction** is part of the dimensionality process, in which an initial set of raw data is broken down and reduced to more manageable batches. So, when you want to treat it will be easier. **Image classification** is the process of classifying and naming groups of pixels or vectors within an image based on specific rules. The classification law can be formulated using one or more spectral or compositional properties. **Image recognition** a subcategory of computer vision and Artificial Intelligence, represents a set of methods for detecting and analyzing images to enable the automation of a specific task. It is a technology that can identify places, people, objects and many other types of elements within an image and drawing conclusions from them by analyzing them.

III. Problem definition

A. Problem Statement

Assuming the violation recovery follow-up takes a set of iterations. In the 1st iteration, the violation exists as it is, with a number, n, of features, where n is an integer > 0. In the 2nd iteration, the violation exists as it is, but with fewer number, n-x, of features, where x is an integer > 0. In the last iteration, the violation will be removed and be of zero features, i.e. n = 0. The follow-up process of the violations iterations by a human reporter is difficult to implement and difficult to recognize the difference between features of nth iteration and of (n+1)th iteration. This is because the human **reporter** cannot distinguish the number of features of the first iteration and in following iteration by human eye. **Figure (2)** shows this situation. While this can be done by technology, the AI and its subsidiaries.

Direction of violation recovery, number of iteration = n, n-1, n-2,… 3, 2, 0

Violation Detection, 1st iteration	**Violation Follow-up, 2nd iteration**		**Violation Follow-up, Last iteration**
$shape_i$	**$shape_{i+1}$**		**$shape_{final}$**
Shape with number of *features = n >0*	Shape with number of *features= m, m < n*	…	Shape with number of *features = 0*
$Shape = \sum_{k=0}^{n} feature_k$, $n > 0$	$Shape = \sum_{k=0}^{m} feature_k$, $m = n - x, x > 0$		$Shape = \sum_{k=0}^{k} feature_k$ $k = 0$

Figure 2: The gradual Steps/Iterations to Follow-up Violation Recovery

B. The problem formulation can be as follows:

Let $shape_i$ be the recognized violation in iteration i.
Let $shape_{i+1}$ be the same recognized violation in iteration i+1.
Let $shape_{final}$ be the same recognized violation in final iteration.

On the other hand, any shape consists of a set of features, so:

$Shape_i = \sum_{k=0}^{n} feature_k$ where n is the number of features in i^{th} shape in the violation.

$Shape_{i+1} = \sum_{k=0}^{m} feature_k$, where m = n – x, x is an integer > 0, m is the number of features in $i+1^{th}$ shape in the violation.

To insure the violation is going to be recovered, it should be m < n, and to insure the violation has been recovered, it should be m = 0.

Accordingly, it is required to discriminate between $shape_i$ and $shape_{i+1}$.

Meanwhile, the features in the first case should be > the features in the subsequent case, and the violation can be completely and absolutely recovered if number of features = 0 (i. e. number of features in $shape_{final}$ is zero).

Then as a conclusion:

if $shape_i$ is equivalent to $shap_{i+1}$, then the violation still does not start to be recovered.
if $shape_i$ is not equivalent to $shap_{i+1}$, and number of features in the violation shape is decreasing, then the violation may or may not recovered,
But:
if shapei$_{+1}$ (i.e. in $shape_{final}$) is equivalent to nothing, then the violation has been recovered.

IV. Proposed System

The proposed system implementation is aimed to facilitate the communication between the ***reporter*** and the ***RGA***. The communication should be reliable in such a way that the reporting is done by only a little set of reporter's clicks. The objective is to automate the violation reporting, only the reporter can click to detect and send the violation image.

A. System Stockholders

There are mainly three stockholders in the application:

- The user of the system, ***Reporter***: through his mobile application, he is responsible about detecting the violation for the first time and follow-up its recovery. The user should login the application after registration process.
- Organization or responsible governmental agency, ***RGA***: The organization responsible for the reported violation recovery, and when the problem is resolved, the organization sends an email to the user to tell them that the violation has been solved.
- The system administration, ***Admin***: the group responsible about administration and management of the system.

B. Basic Functionalities (System Use Cases)

The following use cases describe the main functionalities in the system for both the ***reporter*** and ***RGA***. **Figure (3)**, shows the above actors use case for the citizen, and **Figure (4)**, shows the above actors use case for the organization, RGA.

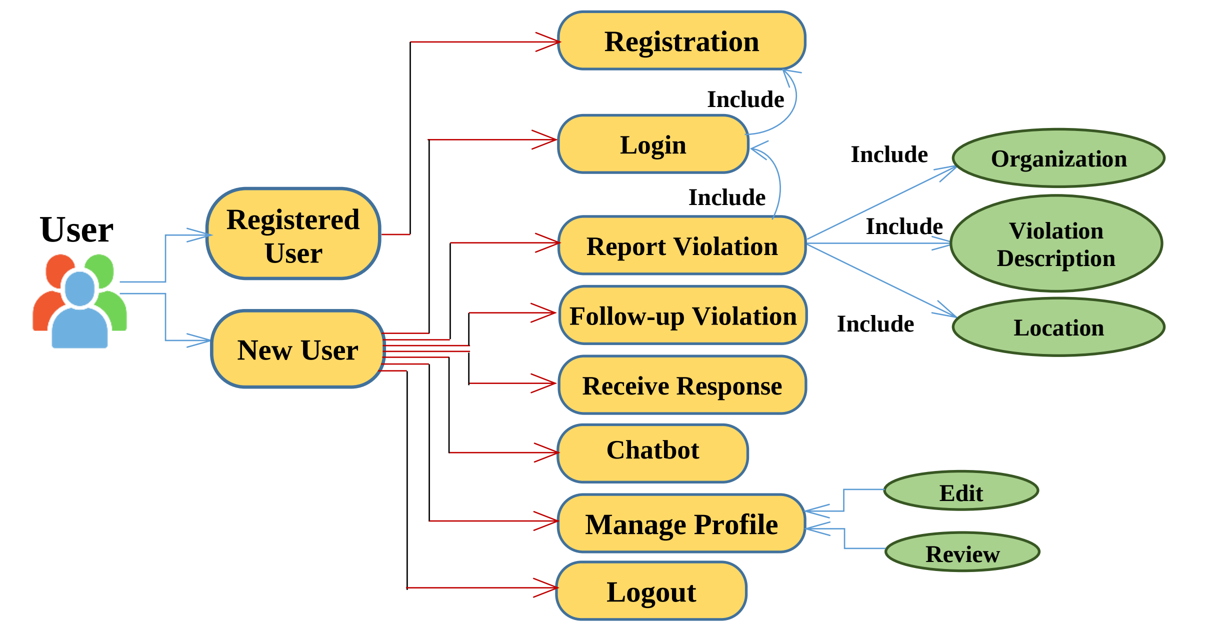


Figure (3): Current System Use Case for the Citizen

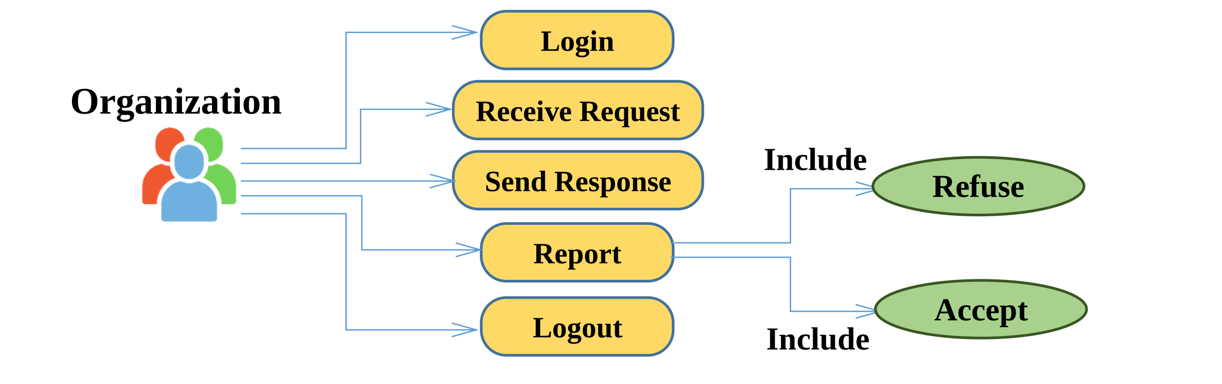


Figure (4): Current System Use Case for the Organization, RGA

C. Proposed system description

As described earlier, the **reporter** capture and send a violation to **RGA**. More than one **reporter** may capture and send a same violation in one or different times, refer to **Figure (5)**. On the other hand, a one **reporter** may capture and send the same violation more than once in different times when he is going to follow-up the violation recovery, in which there may exist a slight difference (Δdiff) between them, refer to **Figure (6)**. This needs the reporter to compare the currently issued violation with all violations previously reported. This can be done efficiently and accurately, and timely, by means of image recognition technology than by reporter physical eye.

D. System Business Requirements

The basic functional requirements are the automated recognition between two same captured images or photos for same or different violations, as stated in the problem definition. The objectives are to automate the violation reporting, to automate the recognition between two reported violations, and to detect whether the violation has been recovered or not yet. Only the reporter can click to detect the violation image. This can, after the capturing image or photo by the reporter, be achieved by:

- Definition, description, and registration of the violation image **in the system database**, in which the violation is identified and defined by the related attributes; violation ID, title, location, type, level of reporting, repetition, status, and reported date and time.

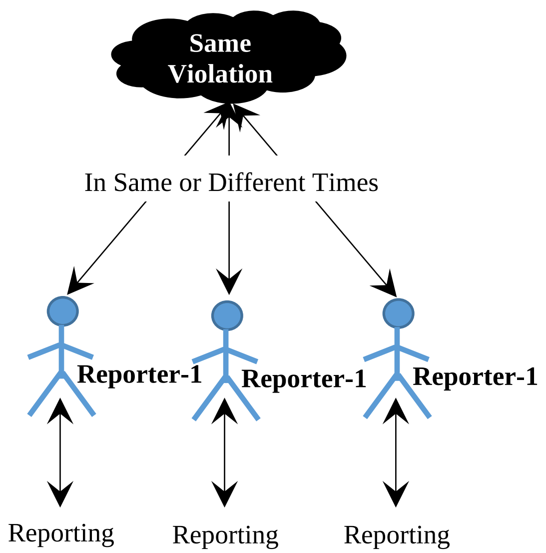


Figure 5: More Than One **Reporter** may capture and send Same Violation in One or Different Times

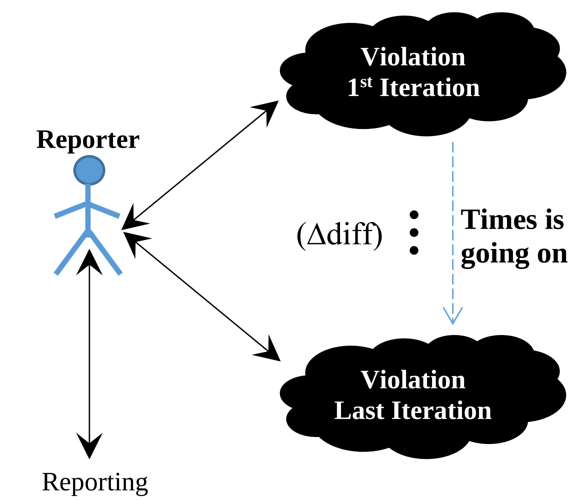


Figure 6: reporter may capture and send the same violation more than once in different times

- Violation image processing (**segmentation, Feature extraction, Image classification, and Image recognition).** As a result, the image processing identifies each registered violation from point of view of its number and nature of constituent features. It allows to distinguish between each new issued violation with all the previously registered violations. This is to allow to discover the matching between two of them to define if there are two typical violations.

- Violation catalogue consultation and classification, in which the violation is classified according to violation catalogue basic classifications. Violation catalogue contains all possible and available violations classified according to general main and subtypes. Refer to **Table (1)**
- Image comparison with all previously recorded violations in the system database, and status identification (still not recovered, slightly recovered, completely recovered). Each time a violation is compared with previously detected violations, it should be declared whether it match with an early registered one or not. If it is registered before, it should be treated according to the following criteria:
  - If the same violation has been reported since three days and not recovered partially, it should be reported to second level of RGA.
  - If the same violation has been reported since more than three days and not recovered completely should be reported to third level of RGA.
  - Same violation reported in less than three days should be neglected.
- Reporting the status to the RGA in case it is still not recovered, slightly recovered, or completely recovered.
- Reporting the recovery status of the violation to the reporter.

Table 1: System DB; Violation Definition in system Catalogue Main and sub category

From Catalogue		**violation ID**	**violation title**	**violation location**	**violation type**	**…**	**reported date and time**
Main Category	**Sub Category**						

Note: Main and sub category is retrieved from system catalogue (mmmm)

It is required to avoid confusion between two similar featured violations in same place, and to allow distinguish between different statuses of same violation. To avoid this, a catalogue of violations is created. It contains all possible and available violations classified according to main and subtypes. Each detected violation can be classified according to such catalogue classifications. This catalogue should be managed and maintained by ***system admin*** for continues reviews and update.

For the sake of system management requirements, the system admin should do a set of mining, appropriate data analytics, and generate a set of reports and statistics about the violations, to indicate patterns and volumes of violations classified by violation, classified by title, location, type, level of reporting, repetition rates, status, and reported date and time.

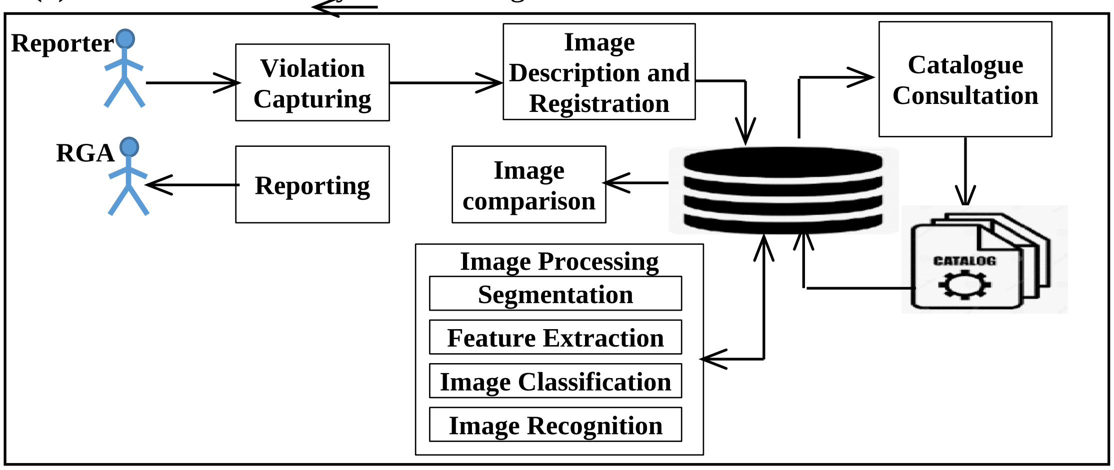
F. System SW Architecture

The system consists of the following modules:

- ***Capturing process,*** in which the violation image is captured, violation is defined, and registered in database.
- ***Image coding***, in which the violation image is treated by the image recognition facility to generate a unique code for that image over the system, then registering such code in the system database.
- ***Image comparison***, in which the recently captured image is compared with all previously registered images to distinguish if there are some identical images. If so, the above criteria is applied.

- ***Violation reporting***, in which the violation is reported to the RGA appropriate level, to manage the reporting to the next levels in RGA if needed.

Figure (7) shows the Current System SW Organization.



V. System Measurements and Results and Analysis

A group of measurements has been done under a set of assumptions as follows:

Figure 7: System Technical Architecture

Assumptions:

- In average, RGA recovers a violation after reporting for the first time and 3 follow-up times.
- The total processing time can be calculated according to the following equations:

  $T_{PS} = T_{VC} + T_{FTR} + T_{CCS} + T_{MS} + T_{VFC} + T_{FUR}$, for the case of human reporter processing

  $T_{PH} = T_{VC} + T_{FTR} + T_{CCH} + T_{MH} + T_{VFC} + T_{FUR}$, for the case of human reporter processing

  Where:

  T_{PS}…… is the Total processing time calculated by the system

  T_{PH}…… is the Total processing time calculated by the human reporter

  T_{VC}…… is the violation capturing time, ≈45 sec.

  T_{FTR}…… is the First-time reporting time, ≈ 3 sec.

  T_{CCS}…… is the catalogue consultation time, by the system, ≈ 1 sec.

  T_{CCH}…… is the catalogue consultation time, by the human reporter, ≈ 9 sec.

  T_{MS}…… is the matching time. The comparison time between two subsequent reported violations by the system. This need to match the reported violation with all recorded violations in system database, ≈ **1000operations/** sec.

  T_{MH}…… is the matching time. The comparison time between two subsequent violations by the human reporte.

  T_{VFC}…… is the violation Follow-up capturing time, ≈45 sec.

  T_{FUR}…… is the following-up reporting time, ≈ 3 sec.

- The total processing time, will be calculated for both the system as T_{PS}, and when processed by the human reporter as T_{PH}.
- The system database will be grown up with violations according to the frequency of violation reporting, in the start-up, there will contain no violations records, and subsequently, the number of records will be increased by the number of daily reported violations. This will affect the value of the matching time, T_{MS}, and T_{MH}.

- Number of violations detected by one reporter in a day is ***n***.
- Number of reporters that may use the system is ***m***.
- The technical specifications of the employed computer is as follows:
  1000 operations/seconds,

The total processing time has been calculated according to the above equations and assumption for thirty days for both the case of human reporter processing and for the case of human reporter processing. **Annex (A)** contains such calculations. It is found that the processing time by the system is about 13% of that by the human reporter. This ration is decreased as the number of violations increased and the number of reporter's increases. **Figure (8)** shows the relation of the processing time between the system and the human reporter. **Figure (9)** shows the ratio between the system and the human reporter processing time.

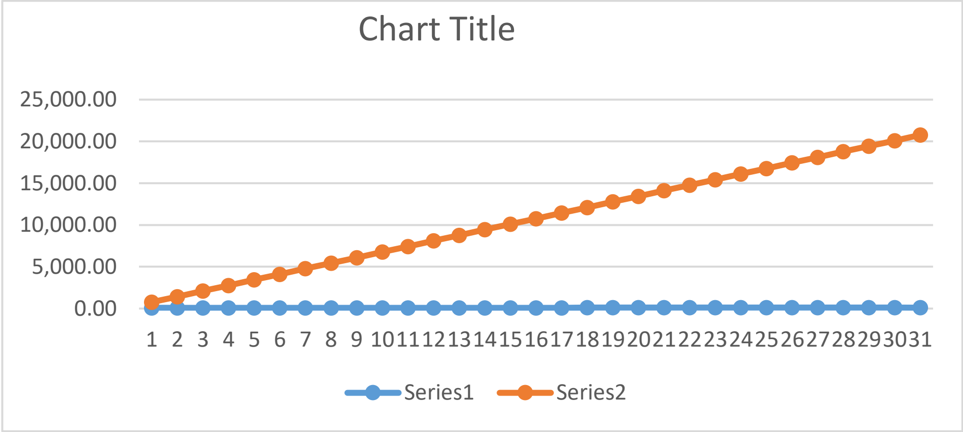


Figure 8: shows the relation of the processing time between the system and the human reporter.

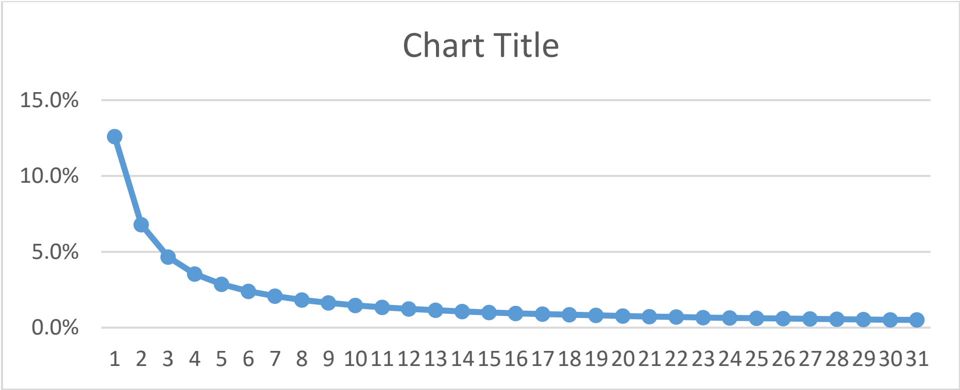


Figure 9: shows the ratio between the system and the human reporter processing time.

IV. Conclusion

A big challenge facing Egypt and other developing countries, it is the environmental violations. They cause the backwardness, disruption and the lateness and fall behind of nations.

As stated in [**1**], in air pollution, it is required to eliminate the levels of the fine particulate matter PM10 and PM2.5 that pose the greatest risk to people's health. It is required to minimize the millions of people who seek medical treatment for respiratory problems yearly related to poor air quality and other forms of violations as well.

Due to the difficulty and hardness of reporting, and follow-up overcoming such violations, in this paper the VI technology has been used to facilitate the accuracy and efficiency of this process.

In the proposed system, the process of follow-up is automated by means of VI technology to increase accuracy and efficiency of violation recovery.

A simulation to the proposed system have been built using two equations for processing the performance in both the system processing nd human reporter processing. The result obtained and analysis done to that obtained results proved that the proposed system performance is efficient, the violation reporting is fast enough. Besides the automated system provides the process of violation recovery more accurate. The proposed system has overcome the reporter follow-up manual way of violation recovery. The proposed system proved that the employing of the VI technology has overcome the problems of already existing applications, namely; Violations, Public eye, andKollena Amn.

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Annex (A): The calculation of the total processing time for both the human reporter and for the human reporter.