



ISSN: 0067-2904

A Smart Rehabilitation System (SRS) for Criminals in Smart Cities

Furkan Rabee¹, Saeed Ahmed Khan^{*2,3}

¹ Department of Computer Science, Faculty of Computer Science and Mathematics, University of Kufa, Najaf, Iraq

² Department of Electrical Engineering, Sukkur IBA University, Sindh Pakistan

³ Research professor, Department of Mechanical Engineering, Sungkunkwan University, South Korea

Received: 28/10/2022 Accepted: 6/4/2023 Published: 30/3/2024

Abstract

This article suggests designing an intelligent system to rehabilitate criminals in smart cities, which consists of two categories: the first category suggests a "smart social system," which suggests managing the behaviors (good or bad) of individuals as the root of crime committing. To manage any criminal behavior, we proposed electronic recording of the criminal behavior as the first step, then submitting the criminal with its behavior under proposed rehabilitation theories as the second step to examine the behavior enhancement. This rehabilitation system depends on the prize-and-penalty principle. The penalty in this system is a suspended sentence with community services and fines instead of prison punishment. The second proposed category is constructing the smart system techniques by automating the proposed "smart social system" as a part of the smart police organization under the smart city. The methodology suggests working as a training system to submit the criminals that should be going to prison in standard cases under the proposed rehabilitation system process within a specific period. The proposed system suggested three categories of behaviors into which a prisoner may fall; he might fall into the category of "very bad people," where he needs to go to prison due to his worst actions. Second, he might fall into the "very good person" category, so this system suggests his prison punishment is now over and he is now free and can be released because he has enhanced his behavior. whereas the third category is the gradual process of a person whose actions lie in between these two characteristics; for this scenario, our proposed system suggests that this person needs rehabilitation and training to improve his behavior.

A uniform crossover for the genetic algorithm has been implemented to check the performance of the proposed system. Thus, this could be very useful in improving the crime-preventing systems of the population in smart cities.

Keywords: Smart Cities, Smart Rehabilitation System, Smart People, Smart Society System, uniform crossover, system optimization.

نظام اعادة التأهيل الذكي للمجرمين في المدن الذكية

فرقان حسن صالح ربيع¹، سعيد احمد خان^{2,3}

¹ قسم علوم الحاسوب، كلية علوم الحاسوب والرياضيات، جامعة الكوفة، النجف، العراق

² قسم الهندسة الإلكترونية، جامعة صقر، باكستان

³ استاذ باحث، قسم الهندسة الميكانيكية، جامعة سونغكونوان، كوريا الجنوبية

*Email: saeedabro@skku.edu

الخلاصة

هذه الورقة تقترح تصميم نظام ذكي لإعادة تأهيل المجرمين في المدن الذكية اطلق عليه : نظام التأهيل الذكي، والذي يتضمن جزئين الجزء الاول هو مقترح نظام اجتماعي ذكي، والذي يقترح ادارة السلوك (الجيد او السيء) للأشخاص كجزر اعتراف الجريمة. لإدارة اي سلوك لمجرم، نحن نقترح تمثيل الالكتروني لسلوك المجرم كخطوة اولى، لإخضاعه تحت نظريات نظام التأهيل المقترحة. نظام التأهيل المقترح يعتمد على مبدأ الثواب والعقاب. العقاب في هذا النظام هو كبديل عن عقوبة السجن ، والمتمثل بخدمة المجتمع والغرامات . الثواب يمثل نقطة لتحسين السلوك الى الافضل. الجزء الثاني من مقترح البحث هو بناء النظام الذكي وذلك بأتمتة النظام الاجتماعي المقترح كجزء من نظام الشرطة الذكي تحت المدينة الذكية. طريقة التنفيذ تقترح العمل كنظام تعليم ذكي لإخضاع المجرمين اللذين من المفترض ان يدخلوا السجن في الحالات الطبيعية لنظام التأهيل المقترح خلال فترات معينة. عند نهاية كل فترة مخرجات النظام تنتج ثلاث انواع من الاشخاص: اشخاص بسلوك سيء جدا ، وهؤلاء يجب ان يدخلوا السجن لانهم لم يحسنوا من سلوكهم ابدأ بل ازداد السلوك سوءا. الصنف الثاني اشخاص بسلوك جيد جدا ، وهؤلاء سيفرج عنهم ويعتبرون احرار لانهم حسنوا من سلوكهم بشكل كبير، والصنف الثالث هم اشخاص ظل سلوكهم بنفس المستوى لذلك هؤلاء يحتاجون الى ان يعادوا الى التأهيل لمعرفة مصيرهم. تم ادخال الخوارزميات الجينية في هذا النظام لبيان كفاءة النظام ، وتبين ان النظام المقترح يتوافق مع الخوارزميات الجينية وقد يكون نظام تأهيل مناسب للتأهيل.

1. Introduction and Background

1.1. Introduction

The social structure of the society is compromised when crimes are happening, and that is why people migrate from one place to another for a peaceful life. There are various other issues and repercussions of crimes affecting human life. Only a low-crime society could be a developed and prospering society where the ratio of crimes is negligible. Crimes are common social problems affecting the quality of life. The people always change their houses (or homelands) to find new places if they know or feel that their territories are not safe or under threat, where the crimes affect the reputation and economy of the country. The financial burdens are placed on the state by the need for additional police and courts [1]. Therefore, the governments used different punishments to prevent the crimes, and the punishments varied between countries, such as prison, probation, community service, and fines. Every country has its own laws followed by the international laws suggested by the UNO and the International Court of Justice for prison sentences and community sentences, which may vary from country to country. The prison or jail is a well-known and utilized punishment in countries, sometimes called "incarceration." Incarceration is the state of being confined in prison, typically as punishment for a crime [2]. Every country in the world has a prison system of some sort. However, the exact nature of that system and the number of prisoners incarcerated within it vary tremendously from country to country [2].

With more than 2 million prisoners around the country, the United States tops the globe in overall incarceration (per data released in October 2021 by the World Prison Brief). This represents around a quarter of the world's total jail population, resulting in an imprisonment rate of 629 persons per 100,000, the highest in the world [2].

1.2. Community service (CS)

In the United States, community service (CS) first became popular in the 1960s (McDonald, 1986), with the goal of providing an alternative to incarceration or fines for less serious criminals, such as those convicted of traffic violations, petty theft, and other nonviolent offenses [3]. Although CS has been used in this country for nearly four decades as

a discipline for relatively less serious offenders, it is still a relatively new approach, which opens more fronts for research work to be done and necessary correctional interventions to be made for developing a sustainable system [3].

The sentence is widely viewed as a good sanction because it spares infrequent criminals who do not require rehabilitation from the personal and financial consequences of prison [4]. In the Dutch criminal court system, community service must benefit the community and be undertaken in the offender's spare time [5] [6]. Since 2001, community service can be used as a principal sentence rather than being used just to substitute for short-term imprisonment [5]. The number of criminals sentenced to community service in the Netherlands grew dramatically from 14,485 in 1997 to 32,590 in 2007 [5] [7].

In 2009, a Dutch research paper [8] was published in Dutch. According to research published in [5], more than 60% of criminals recidivate after serving time in jail, compared to 40% of those sentenced to community service [5].

Domestic violence is also included in the category of crimes where it is done either physically or mentally these days. Whereas physical abuse is evident from the physical marks left on the body of the victim, which can be clearly witnessed, and those can be proved in a court of justice as crimes, there are some doubts about whether a crime has happened or not during mental abuse (a non-physical abuse) such as psychological and emotional torture. A recent study shows that

Community service as a form of punishment that will encourage the offender's repentance and preserve the sanctity of marriage. The punishment that can be replaced with significant intervention could mold the behavior and emphasize the wrongdoer's responsibility in the healing of a family relationship [9].

1.3. The Information and Communication Technology (ICT) for Smart Cities

Information and communication technology (ICT) is the backbone of smart cities, as it supports the effective utilization of existing resources through developing technologies related to civilizations. The nature of technology adoption is seen as aiding cities in making socio-technical transformations and mutating into smart cities.

Due to the advancement and diversity of technology in various fields, many terms have been introduced to represent a single identification of these technologies. Smart cities, according to the European Commission (EC), are placed under a single term that deals with "a technology that uplifts its residents and boosts the socio-economic conditions of a country by utilizing digital and communication technologies from the existing networks and services more efficiently" [10]. The concept of developing smart cities is to reshape the socio-cultural, socio-economic, and socio-technological structures of society so that its residents can live a quality life. Developing smart cities also opens a competitive environment amongst other cities and industries to face the rising problems of energy shortage and climate change. Therefore, a smart city is an entrepreneurial city more prone to fraud and crimes; therefore, ICT plays the main role in controlling crime to protect people and their businesses and make such cities safer and more secure because "the smart cities intend to be entrepreneurial cities" [11].

Many concepts and applications have been supported by ICT, such as cloud computing, the Internet of Things (IoT), mobile computing, mobile crowd sensing (MCS), and others that could be applicable under smart cities [11–14].

1.4. Smart Security

As a result, (public and private) security companies are already adjusting to these trends and implementing new technologies to improve their responsiveness, legitimacy, and overall efficiency [15]. As a result, the Internet of Things in smart cities is advantageous to security stakeholders.

The implementation of sophisticated and secure camera, sensor, and communication systems to effectively monitor public spaces is one of the solutions a "smart city" might provide for improving public safety. Communities could also gain from an increase in community confidence in law enforcement [16].

2. Related Works

Theoretical proposals for a synergy between smart cities, policing, criminal investigation, and criminal intelligence were presented by Prisljan and Slak [17]. Researchers have presented a survey about the crimes and smart city techniques used to detect the criminals depending on the sensors and biometric analysis; moreover, they have presented work on detecting, tracking, making registrations, and matching the data or biometrics for criminals. Their proposed work still involves detecting and matching the biometrics to help with criminal intelligence.

Gerard V. et al. [14] worked on urban security in smart cities. Their findings focused on the detection, data collection, and matching of biometrics, and they concluded that the smart city technologies had a positive result from the description and evaluation of the preventive measures.

Wang, J. et al. [15] suggested an IoT-based elastic surveillance system that uses edge computing to elastically alter compute capacity and dynamically route data to appropriate edge servers for real-time surveillance applications.

Yigitcanlar, T. et al. [18] presented an understanding of smart cities by identifying and linking their three main drivers (society, technology, and policies) to their desired outcomes: well-being, sustainability, livability, and governance.

Bouffard et al. [3] presented a review of the community service concept, using an assessment model and an appropriate comparative sample of criminals sentenced to traditional fines to determine whether or not they may be recidivists after the end of the service program.

To investigate the potential application of current digital technologies in assessing and preventing public crime, strategies such as statistical approaches, monitoring, modeling, and questioning have been provided in Truntsevsky, Y.V., et al. [19].

He, J., and H. Zheng [20] employed GAN neural networks to create a prediction model of city floor layouts and corresponding crime distribution maps; this demonstrates that the model can accurately forecast crime concentration regions and predicted crime concentration areas.

Byun, J.Y. et al. [21] propose a smart criminal detection system based on IoT, where they suggest that by studying human emotions, they can detect crimes in real-time. They used the k-means method in their study for predicting real-time crime detection, where emotion recognition, recording, crime detection, visualization, and prediction were all model stages.

Catlett et al. [22] present a design for an approach to detect the high-risk crime regions automatically in urban cities by presenting an algorithm that can forecast the crime trends for each region.

Butt U.M. et al. [23] present a forecast approach for crime detection by identifying and predicting the hotspot-reported crime zones in smart cities. This approach is based on machine learning and involves analyzing and learning from ten years of different crime scenarios.

Rabia Musheer Aziz et al. [24] propose a machine learning-based soft computing regression analysis approach for Indian Crime Data Analysis (ICDA); these regression models can predict the overall number of Indian Penal Code (IPC) crime counts as well as crime counts of various forms of crime.

ToppiReddy et al. [1] offered several visualization tools as well as machine-learning algorithms for predicting crime distribution across a large area. In the first stage, the raw datasets were processed and visualized according to the requirements. Afterwards, machine learning algorithms were used to extract knowledge from these large datasets and discover the hidden relationships among the data.

Gilbert Syswerda [25] presents a uniform crossover operator that is as genetic as one-point and two-point crossover; this operator is effective in optimization in different fields of science.

Moreover, Abid Hussain et al. [26] present two new crossover operators for genetic algorithms; one of them is based on the natural concept of crossover, and the other proposed scheme is the extension of two-point crossover with the concept of the multiplication rule.

Yirui Jiang et al. [27] presented a model to allocate the inspector in smart cities and optimize the patrol paths. The optimization method reduces the average time and the inspector number.

F. Rabee and I. S. Ibrahim [28] present a Hadoop MapReduce-based system to handle large amounts of data by categorizing the residents of smart cities based on their behaviors (both good and bad), with the data coming from multiple sources with diverse categories. The suggested method encourages the use of a reinhabiting system to address these categories and enhance human behavior.

The main types of documentary evidence in courts for any incident or crime are pictures and recordings. One of the most frequent methods of video alteration in the temporal domain is inter-frame video faking. Techniques for deep learning (DL) have been successfully used to analyze and interpret visual media. The three-dimensional convolutional neural network serves as the foundation for the suggested model by Oraibi and Radhi [29].

The primary contribution of the Burhan et al. [30] study is to use a lifetime-aware model to handle the optimization problem of task allocation in the IoT. The suggested task distribution protocol uses a genetic algorithm. A modified uniform crossover and an individual representation adapted to the problem are created for the suggested algorithm.

The presented work of researchers so far is based on studies focusing on psychological-social theoretical models, empirical and statistical research, and is relying on innovative technologies under the “smart city” concept.

whereas computer-based studies depend on artificial intelligence, machine learning, the Internet of Things, and smart cities, where these studies are limited in terms of detecting, predicting, and data collection.

This article proposed a smart training system to rehabilitate the criminals, prevent the criminal from committing the crime, and engage them in society by depending on suspending sentences and replacing the punishment with community services or fines.

3. Contribution

The proposed system is the first model for a smart city framework to manage criminals' and people's behavior. Moreover, this study produces a new optimizing method called Rehabilitation Training System (RTS), as mentioned in Section 6.1, that can be applied to any system as an optimization approach.

4. Problem Statements

This study released two different problem statements:

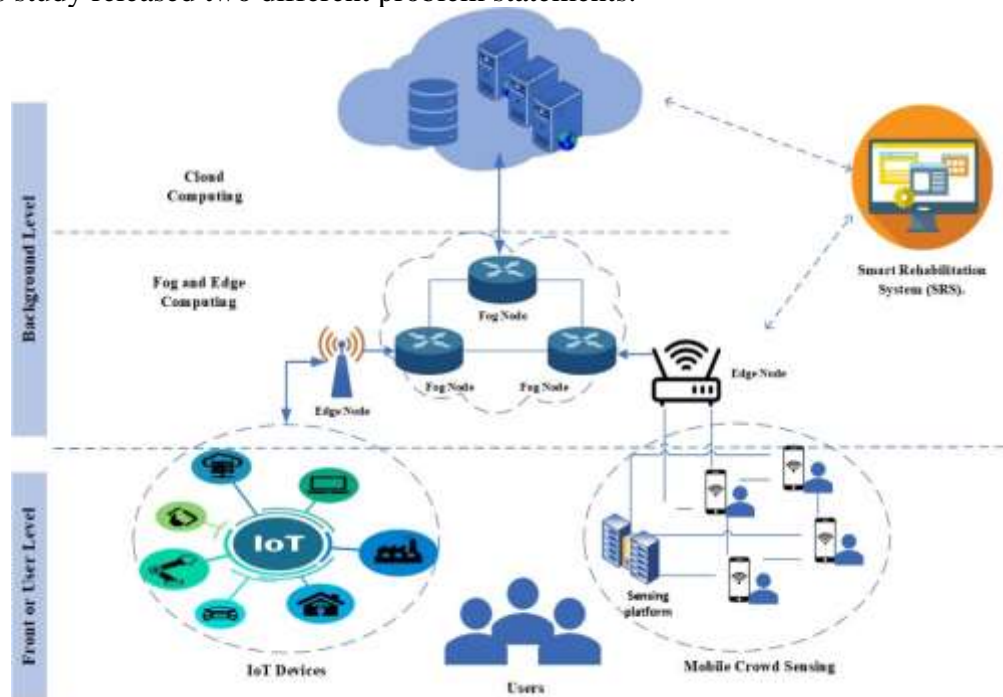


Figure 1: Proposed system (SRS) position

1- Society problem: the mass of criminals as well as incarceration can result in several logistical challenges, such as prison overcrowding, which may become prone to increasing health hazards and lowering the psychological well-being of people who are kept in custody [2]. Thus, we suggest here smart society solutions to reduce the prisons' overcrowding by developing new algorithms that can be used to establish smart cities.

2- Technical problem: the research on developing an efficient system for minimizing and controlling crimes in smart cities. Many researchers have not addressed this problem as part of the basic work of smart cities. Instead, they confined themselves to the field of detecting, collecting data, and predicting crimes. Also, the researchers have not considered building a smart police system to manage criminals' behavior. So, this article proposes a system for

managing the criminal's behavior as a new part of smart cities related to police organizations responsible for rehabilitating the criminals under the rehabilitation system, which can be applied to prisoners in prison or before entering prison.

5. Smart Rehabilitation System

In this section, we have discussed the detailed structure of the proposed system, called the Smart Rehabilitation System (SRS).

5.1. Proposed System Scope

This proposed system positioned itself concerning various fields in cloud computing, such as mobile computing, the Internet of Things (IoT), mobile crowdsensing (MCS), edge computing, fog computing clouds, etc., for decision-making techniques. Figure 1 shows our perspective on the smart city and the position of the proposed SRS. In this system, the data collection, detection, and other requirements are already received from the front level (or user lever), which were not considered for this study.

SRS contents

This section shows the contents of the proposed system, including the technical rules and algorithms for SRS, where the system's contents are described in Figure 2.

The term "crime" in this article refers to medium and light crimes, and we don't suppose it could be suitable for serious crimes such as murders.

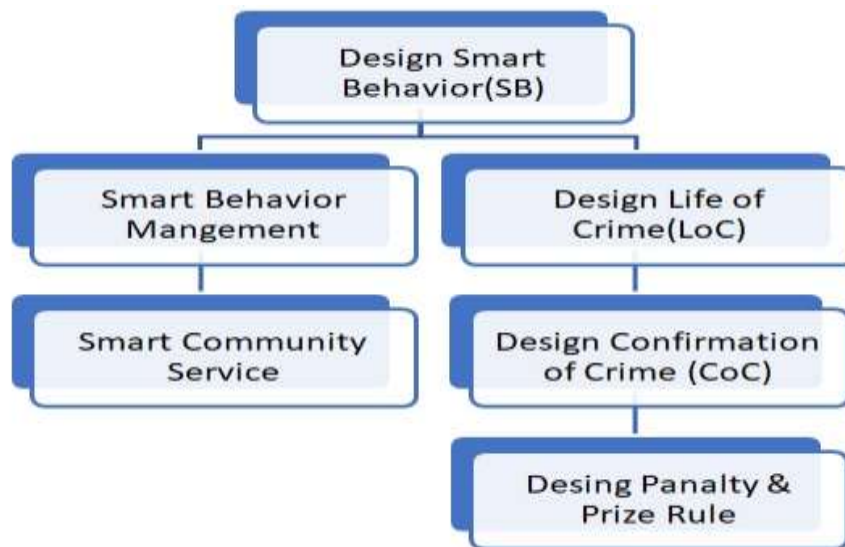


Figure 2: SRS contents

5.2. Smart Population setup

Suppose that a smart city with Y population {P₁, P₂, P₃ P_n} persons all persons or part of them suppose they are under a rehabilitation system, each person classifying as Guilty-Person, non-Guilty-person, suspect-person depends on Self Criminality Record(SCR).

On the other hand, each person has two main types of properties called person behavior, which is divided into good behavior (GB) and bad behavior (BB), where the good behavior contains all the community services that have been done throughout his life, as:

$$GB_p = \sum_{i=1}^n cs \tag{1}$$

In contrast, "bad behavior" refers to all types of crime throughout his life. as

$$BB_p = \sum_{i=1}^m crime \tag{2}$$

where *p* refers to the person related to *GB* and *BB*, *n* refers to the number of community

services (cs), m refers to the number of crimes.

Where GB and BB are represented as percentages, their sum should equal one hundred.

Smart Behavior (SB)

$$SB \equiv GB_r + BB_r = 100\% \tag{3}$$

from SB the person (or the criminal) defined in the SRS system, and depending on this property, a record would be generated for any person called a Smart Criminal Record (SCR). According to SCR, any person can be classified as a criminal or not if his or her bad behavior outweighs his or her good behavior. There are three values for SCR shown in equation (4).

$$SCR = \begin{cases} 1 & \text{if } GB \geq BB \\ 0 & \text{if } GB < BB \\ -1 & \text{elsewhere} \end{cases} \tag{4}$$

Figure 3 shows an example of the difference between a guilty and non-guilty person.

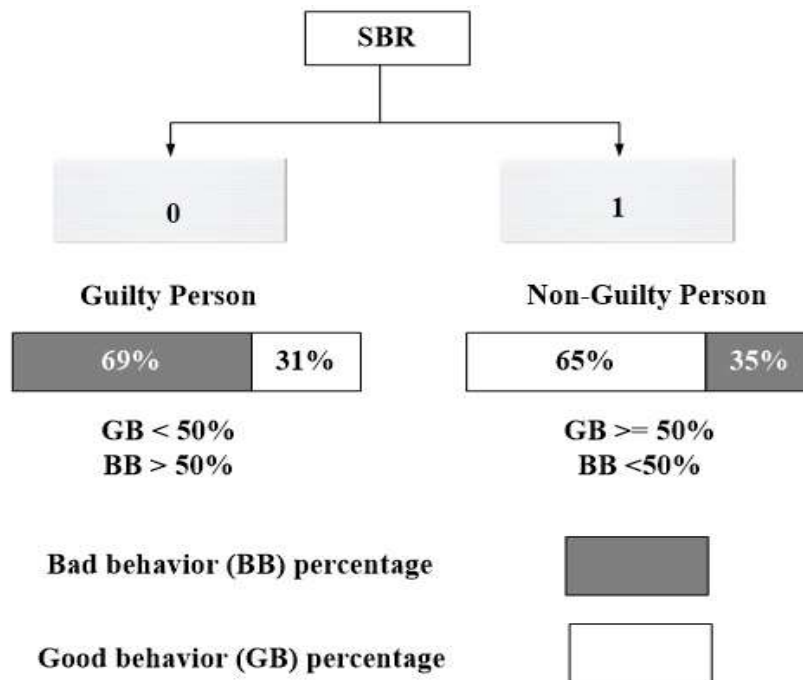


Figure 3: Differences between Non-Guilty and Guilty Persons

5.3. Smart Behavior (SB) Design

This part shows how to build the behavior of a smart population. As mentioned in equation 3, any person has a smart record, where each person will get initial values for the SCR from his history before engaging in the SRS system.

In this system, the SCR will change if SB changes, the BB will increase if any person commits a new crime after getting confirmation about the crime committed (as will be mentioned next), and at the same time, the GB will decrease to keep the SB value equal to 100%. In contrast, if any person tries to improve their GB (or does any community service), the GB will increase and the BB will decrease. The mechanism to design SCR and SB is shown in Figure 4.

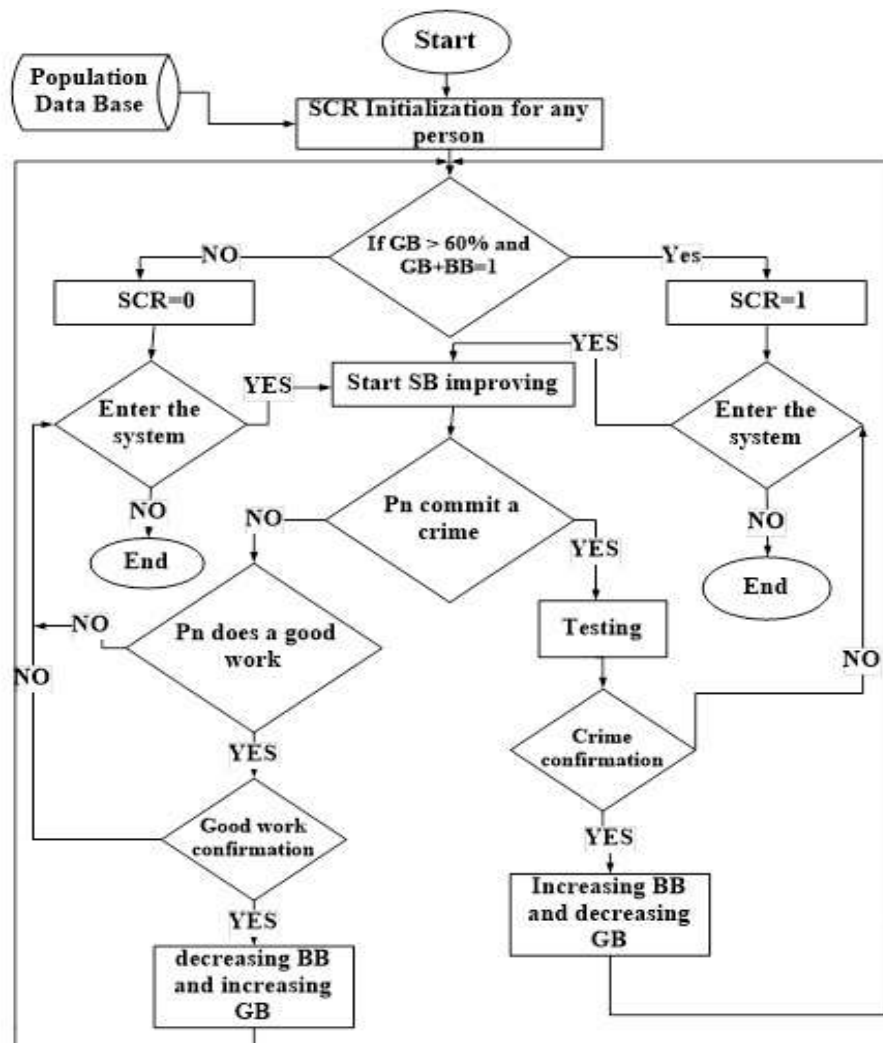


Figure 4: Smart Person's behavior flowchart

5.4. Crime Management System Design

This part describes how to build the crime management system algorithms, where this system depends on the life of the crime, confirmation of the crime, and criminal penalty and prize.

5.4.1 Life of Crime (LoC)

This part refers to the permission period that could be given to the criminal if he commits any crime, where the person will provide a period without adding the crime to the person's SCR. The reason is to give him a second chance if that crime was committed unintentionally or to give the criminal time to regret it.

If that person commits a crime in the permission period, the crime will be confirmed, and the new crime will be in progress with a new LoC, as shown in scenario 1. Add to that, the appropriate punishment will apply to that person.

So, if no crime is committed within the permission period, the last crime will be canceled, and no punishment will be imposed. This permission is called Life of Crime (LoC)². Example 1 shows the procedure for LoC.

² LoC depends on the communities and countries or the police security system, which means the LoC may increase or decrease or even can't be allowed if it is not suitable.

5.4.2 Confirmation of Crime (CoC)

Suppose a crime or several crimes are committed within the LoC. In that case, the previous crime will be proved, with an appropriate penalty for each crime. For new crimes, a new LoC would be applied, depending on the SCR's bad behavior (BB) property. Scenario 1 shows how the CoC works in steps.

Scenario 1: Assume P_n , who has a GB of 68% and a BB of 32%, committed a crime of type A. What will the procedures be if he enrolls in the SRS system to manage the CoC? Suppose that the permission time is equal to ten days.

From SB properties, the SCR status of this P_n will be equal to 1, which means he is a non-guilty person. And the permission time refers to the default LoC. Furthermore, the following algorithm describes the CoC for this scenario:

Algorithm

Step 1: Input Person P_n with 68% GB, 32% BB and status=1

Step 2: When P_n commits a crime type A

Stature SCR change to -1 and P_n is suspect person (SSP).

Crime suspended, wait 10 days.

Step3: if SSP didn't committing any crime

Crime canceled and Stature SCR change to 1

Step 4: if SSP commits a crime

The crime has been confirmed

Step 5: Call Smart Behavior Management System

Suspend new crime committed within LoC, P_n is Guilty Person (GP_{NC}) and give new permission

New LoC \leftarrow default LoC + GB

Updating SB

End.

5.4.3 Penalty and Prize Rule

The proposed system is based on the penalty and prize method to govern the people in smart cities; thus, there is a penalty for the guilty person to prevent him from repeating the crime. Also, there is a prize or reward for the person who has a brilliant attitude. Therefore, this system has two types of penalties for suspending sentences and one type of reward. They are as follows:

1. *Smart Fine Penalty (SFP):*

This type of penalty is taken from the guilty person after the crime is committed. The fine in this system passes in two steps: deduction and public rights bank.

- The Fine Deduction (FD): This fine takes money from the guilty person's wallet to support the SP and takes an initial amount before engaging in the SRS. The value of this wallet will increase or decrease depending on punishments or promotions.

- Public Right Bank (PRB): the portion of the fine taken from the guilty person's wallet will be charged to the Smart Cities Wallet (SCW) as a common resource, which will be a service to the city.

For each person who has a smart wallet (SW), the system shall deduct or compensate the fine depending on the person's status (guilty or not guilty), which has been described in equation (5).

$$SW^{GP} = SW^{GP} - FD \quad (5)$$

$$SCW_{new} = SCW_{old} - PRF_A \quad (6)$$

Where the SW GP is the wallet of the guilty person, SCW_{new} is the wallet of SCW.

2. *Other Penalty*

This study proposes two other penalties for guilty persons (GP). One penalty is engaging the GP in community service. After applying the rehabilitation system, if the result of the GP is positive behavior, the person would be free from prison. In other words, if this result worsens the previous one, the second penalty shall be applied. As a percentage, any guilty person with 90% of his BB should be sentenced to physical punishment, such as prison, whereas this category falls under the Very Bad Behavior (VBB) category.

3. *System Reword*

In contrast to punishment, there is a reward for rehabilitated criminals; we suggest that anyone with a GB of up to 90% would get their freedom, and that category falls under the "very good behavior" (VGB) category.

5.5. Behavior Enhancement design

Here we discuss the change in personal behavior in two parts, as explained in the subsections of this section.

5.5.1 Smart Behavior (SB) Management

This section describes how SB manages the effect of the crime, whereas GB and BB would change every crime committed.

In this system, suppose there are three kinds of crime, and depending on the strength of the crime, both strengths and kinds of crime could change from one society to another. Referring to the strength of the crime by weight, we propose three weights of crime levels such as "high," "medium," and "light," where each of them reflects a particular crime committed by a person. The weights were suggested at a small percentage to avoid a significant change in each crime's SB.

Moreover, we suppose to manage the SB as a way of ensuring uniform crossover of GB and BB, so present the following equations:

The GBs refer as :

$$GB_{ai} = \{GB_{11}, GB_{22} \dots \dots \dots GB_{nn}\} \tag{7}$$

$$BB_{ai} = \{BB_{11}, BB_{22} \dots \dots \dots BB_{nn}\} \tag{8}$$

Where *n* refers to the number of persons with two properties each.

We suppose that there are two small values for crime or community service variables:

$$W = \begin{cases} \alpha \text{ Good work} \\ \beta \text{ Bad work} \end{cases} \tag{9}$$

If any person commits a crime

$$\beta_i = \{\beta_1, \beta_2 \dots \dots \dots \beta_n\} \tag{10}$$

Now we can apply the crossover to get a new generation of properties, as in the following equations:

$$GB_{nn}^{new} = \begin{bmatrix} GB_{11} - BB_{11} \times \beta_1 \\ GB_{22} - BB_{22} \times \beta_2 \\ \dots \dots \\ \dots \dots \\ GB_{nn} - BB_{nn} \times \beta_n \end{bmatrix} \tag{11}$$

$$BB_{nn}^{new} = \begin{bmatrix} BB_{11} \times \beta_1 + BB_{11} \\ BB_{22} \times \beta_2 + BB_{22} \\ \dots \dots \\ \dots \dots \\ BB_{nn} \times \beta_n + BB_{nn} \end{bmatrix} \tag{12}$$

In the end, it should accumulate both *GB* and *BB* in two cases

$$SB_n^{new} = \begin{bmatrix} GB_{11}^{new} + BB_{11}^{new} \\ \dots \dots \\ \dots \dots \\ GB_{nn}^{new} + BB_{nn}^{new} \end{bmatrix} \tag{13}$$

Scenario 2 explained *SB* management.

Scenario 2: A person with *BB* equal to 30% commits a crime and gets confirmation as a medium crime. What procedures will he face if he enrolls in the *SRS* system to manage his *SB*?

Based on the initial information, this person's *SCR* status is (-1) with *WM* crime. crime will change his *SB* by applying equation (10).

New *BB* = 31.5%, which means that bad behavior increased by 1.5 percentage points after committing a crime. On the other hand, the good behavior will change after a new *GB* equals 68.5 percent, whereas the old *GB* was 70% before committing that crime.

We note that in scenario 2, the *SB* lost a percentage of its good behavior (*GB*).

Advantage: From this scenario, we may assume that each crime committed by any person in Smart City will affect his *SCR*, which means this will affect his daily life, such as study, work, etc., and this person will try to prevent himself from committing any crime, and if he does it by coincidence, there is time for a person to handle himself.

5.5.2 Smart Community Service (SCS)

One of the system's features is to subject the criminal to rehabilitation programs of service work as a form of penalty rather than imprisonment, which is to engage the guilty person to be a responsible citizen and perform community services.

Enhancing the *SB* depends on the following equation:

$$\alpha_i = \{\alpha_1, \alpha_2 \dots \dots \alpha_n\} \tag{14}$$

$$GB_{nn}^{new} = \begin{bmatrix} GB_{11} \times \alpha_1 + GB_{11} \\ GB_{22} \times \alpha_2 + GB_{22} \\ \dots \dots \\ GB_{nn} \times \alpha_n + GB_{nn} \end{bmatrix} \tag{15}$$

$$BB_{nn}^{new} = \begin{bmatrix} BB_{11} - GB_{11} \times \alpha_1 \\ BB_{22} - GB_{22} \times \alpha_2 \\ \dots \dots \\ BB_{nn} - GB_{nn} \times \alpha_n \end{bmatrix} \tag{16}$$

Then, apply equation (13) to accumulate the *GB* and *BB*.

6. Experimental work

6.1. Rehabilitation Training System Deployment

As a case study, the implementation of the proposed system is employed to solve prison overcrowding. We proposed the new idea the first time and claimed that no data sets were

available to offer our proposed information, which we generated randomly for GB and BB to build SB. We have engaged the generated SBs in training to improve the behaviors of SCV depending on the proposed algorithms. Figure 5 shows the training processes used in the experimental study to imply a rehabilitation training system (RTS), which is built up from proposed assumptions and algorithms. All algorithms were written in C++ and executed under Ubuntu 20.04.3 LTS, 64 bit.

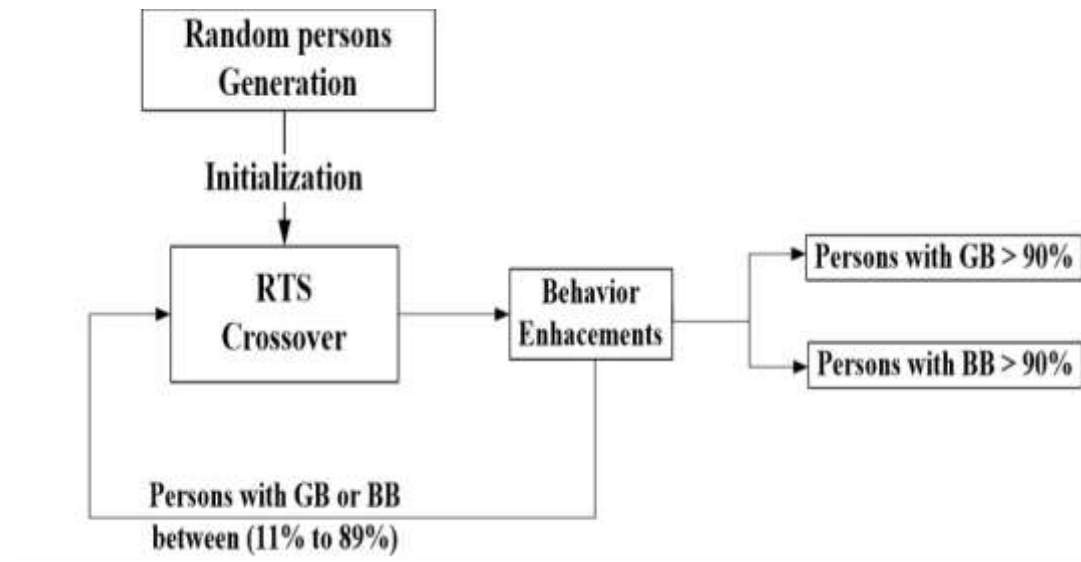


Figure 5: The Rehabilitation Training System (RTS)

From Fig. 5, the output of RTS shows the results of managing the behavior of individuals. There are readings with each iteration of the training, and with each iteration, the output readings classify the persons into three kinds.

The first kind, persons with $GB > 90$, are considered very good-behavior (VGB) persons and are excluded from entering prison and getting freedom.

The second kind of persons with $BB > 90$ are considered to have very bad behavior (VBB), as they cannot improve their behavior; in contrast, they increase their bad behavior, which leads them to go to prison.

The third kind of persons with $GB < 90\%$ and $BB > 10\%$, are called “in-between”; these persons’ behaviors shall need extra time in the rehabilitation system and should take another iteration with RTS.

6.2. System Evaluation

The evaluation for this system starts by generating one hundred million symbols randomly with different values, with the exception of getting to the required percentages as proposed (GB and BB), reaching 3584 symbols to engage them in the rehabilitation training system (RTS). According to the Knoema website [31], this figure of one hundred million criminals is the normal ratio of criminals to the total population in many countries, including China. The RTS was implemented with ten scenarios, each with ten experiments (100 experiments for the whole system), where each procedure produced three outputs, one referring to the quantity of VBB persons, the second to VGB persons, and the third to the in-between persons. The output of each scenario is related to changes in two variables:

a) Variable refers to LoC, where we depend on steps from 1 to 10, where each step refers to three days. For example, let “1”; refer to three days LoC, whereas; the number “2” refers to

six days LoC, and so on. until reaching the maximum number of 10 to refer to 30 days of permission time (LoC).

b) The second variable refers to the period when the criminal undergoes the "Cycle" rehabilitation system. Therefore, this variable refers to how many rounds the criminal takes in the rehabilitation training system (RTS). The numbers described the cycles, ranging from "1" to "10," and each number refers to three months, where the number "1" refers to three-month rehabilitation periods, "2" refers to six-month rehabilitation periods, and so on. The maximum is "10," which refers to three years.

The result of ten scenarios was compared to each other, which means this system could help rehabilitate criminals and reduce the number of people entering prison in different cases. Table 1 and Figure 6 show the distribution of the average values for the whole scenario.

Table 1: The average values for all scenarios of training

Cycles	In-between	VBB	VGB
1	3584	0	0
2	3266.3	151.1	167.6
3	3033.7	262.2	289.1
4	2784.2	378.5	422.3
5	2547.6	499.9	537.5
6	2337.4	605.4	642.2
7	2133.6	706.8	744.6
8	1927.9	806	851.1
9	1785.3	876.3	923.4
10	1649	960.4	1005.6
11	1475.6	1029.4	1080

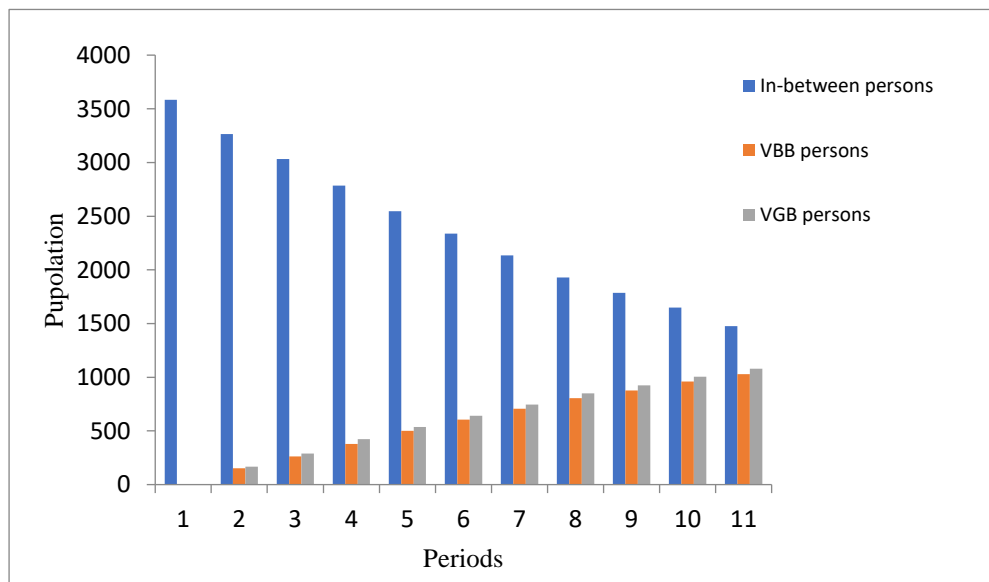


Figure 6: The average output for all scenarios of training

Where Figure 6 shows the population's output every training period cycle, the whole population enters the training system for the first period. Then, from the second period to period eleven, the enhancement increased with two types of behavior persons (VBB and VGB), with still the same amount of population from in-between persons. Thus, this system can reduce the number of people who could go to prison. Moreover, this cycle can be repeated whenever such a system is needed.

6.3. System performance

To check the system’s performance, a genetic algorithm with uniform crossover [25, 26] has been implemented to compare the performance with the proposed work. Figure 7 shows the typical form of a genetic algorithm system with some arrangements equivalent to RTS.

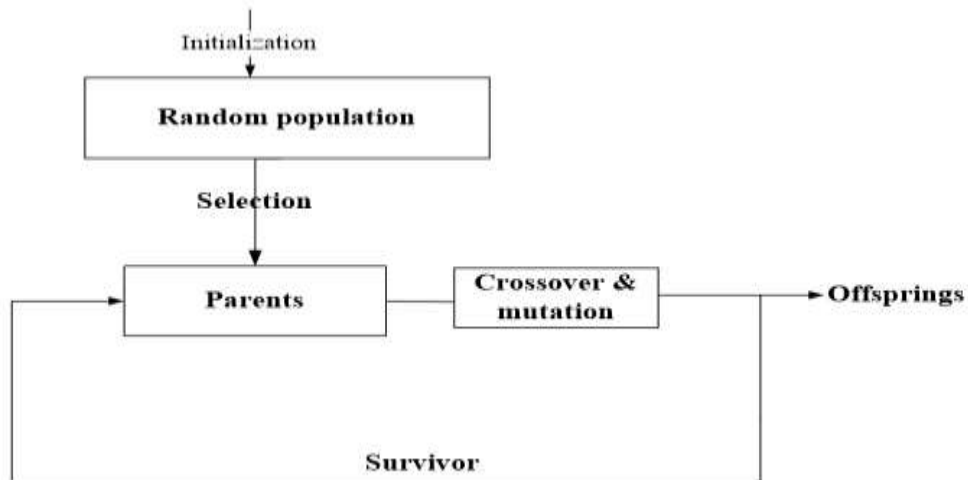


Figure 7: Typical genetic algorithm System

The adoption of uniform crossover has been dependent on the fact that it is compatible with the proposed system. Three thousand eighty population persons were used, and five generations of offspring from the original parents were produced. Figure 8 shows the tree of generations, where in the first generation, only one mutation has happened with RTS; thus, the five generations with this unordered selection are enough to show the outperformance of the proposed system. A selective result has been considered. Figure 9 shows the result of BB affected using uniform crossover for the genetic algorithm (GA) with the proposed crossover of RTS, in case the selection population committed a crime. Figure 10 shows the result of GB affected by using uniform crossover with RTS, in case the selection population did community service.

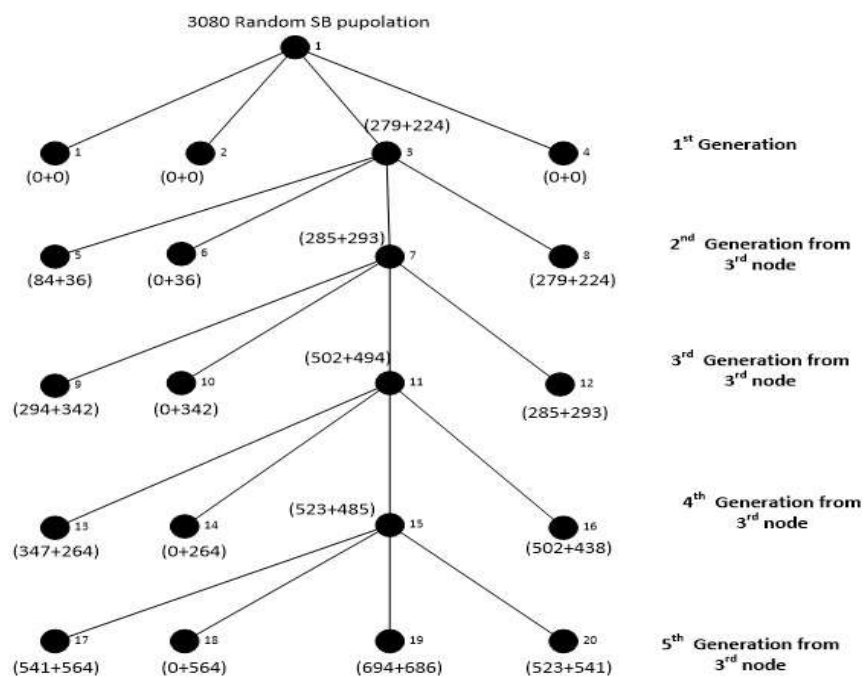


Figure 8: Shows the five generations that produced

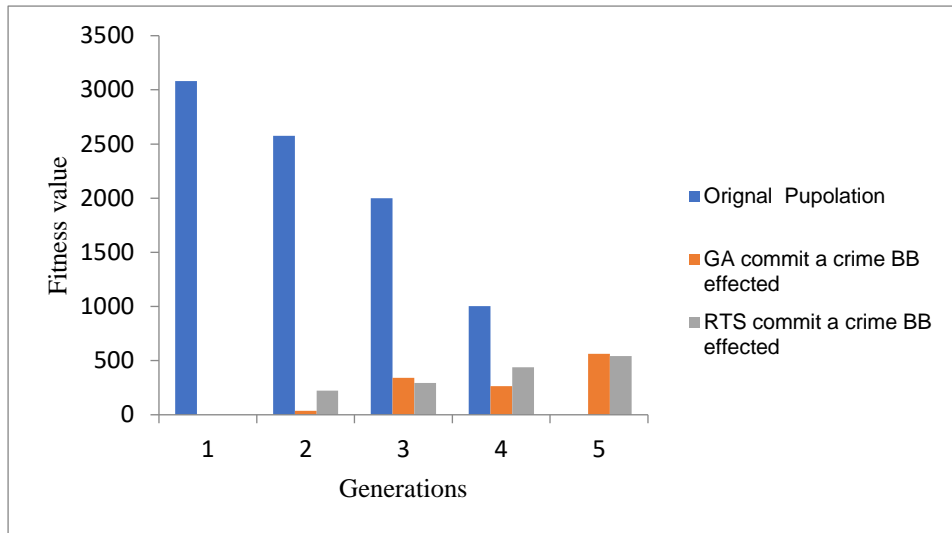


Figure 9: shows the GA vs RTS for committing a crime

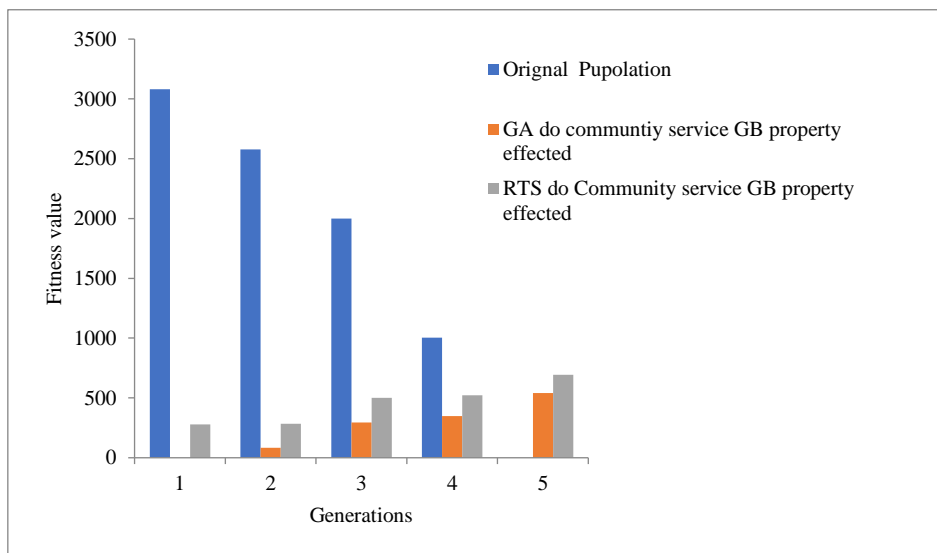


Figure 10: Shows the GA vs RTS for doing a CS.

Figure 9 demonstrated that after five generations, around 18% of the initial population was retrieved as the net population with BB property. Moreover, by the end of the fifth generation, RTS had decreased the proportion of the population with BB in comparison to GA.

On the other hand, the Figure 10 demonstrated that after five generations, around 20% of the initial population was obtained as net population with GB property. Furthermore, by the end of the fifth generation, RTS had increased the proportion of the population in the United Kingdom in comparison to Georgia.

7. Conclusion

In experimental work, the system's evaluation depended on producing random values for many factors, which increased the system's generality. So, depending on an unexpected approach, additional potential ways to demonstrate the performance of the system can be covered.

From the theoretical and experimental parts, the suggested system reported sufficiently well to:

1. Fulfills the missing part in developing smart cities related to traditional crimes by giving a new prospect for the punishment system of the criminals through system automation.
2. The systems SRS and RTS can play an essential role in improving people's behavior as a general goal and for criminals as a precise goal.
3. Moreover, the system reached the ability to build a smart police establishment to be included in the smart city as a part of smart security; by doing so,
4. Systems can improve people's lives in smart cities by making them more convenient.
5. This system can also be used to prevent crime and enhance people's behavior in smart cities, even if they don't commit any crimes.
6. Increasing the financial balance for smart cities from the fine punishments would thus be a good support to the city and the individuals.
7. Each crime committed by any person in Smart City will affect his SCR, which means this will affect his study, work, etc., in all the fields of his life, and with this, that person will try to prevent himself from committing any crime.
8. If a person commits any crime by coincidence, there is time to handle himself.
9. The training method in RTS could be helpful to any other system for training under machine learning or optimization methods.

References

- [1] B. S. ., G. M. Hitesh Kumar Reddy ToppiReddy, "Crime prediction & monitoring framework based on," *Procedia computer science*, vol. 132, pp. 696-705, 2018.
- [2] "World Prison Brief, I.f.C.J.P.R. Incarceration," December 2021. [Online]. Available: <https://worldpopulationreview.com/country-rankings/incarceration-rates-by-country>.
- [3] L. R. M. Jeffrey A. Bouffard, "The effectiveness of community service sentences compared to," *The Prison Journal*, vol. 87, pp. 171-194, 2007.
- [4] J. Cid, "Suspended sentences in Spain: Decarceration and recidivism," *Probation journal*, vol. 52, pp. 169-179, 2005.
- [5] A. B. P. N. D. N. ., N. T. Hilde Wermink, "Comparing the effects of community service and short-term imprisonment on recidivism: a matched samples approach," *Journal of Experimental Criminology*, vol. 6, pp. 325-349, 2010.
- [6] R. S. F. Michael Tonry, *Sentencing and Sanctions in Western Countries*, New York: Oxford University press, 2001.
- [7] S. Netherlands, "opendata," 2012. [Online]. Available: <https://opendata.cbs.nl/statline/#/CBS/nl/dataset/03727/table..>
- [8] B. S. J. Wartna, "In de oude fout. Over het meten van recidive en het vaststellen van het succes van strafrechtelijke interventies [Making old mistakes. On measuring recidivism and establishing the success of judicial interventions]," *onderzoek en beleid*, 2009.
- [9] S. J. DaleleerKaurRandawar, "Community Service as an Alternative Form of Punishment under the Domestic Violence Act 1994 in Malaysia," *Turkish Journal of Computer and Mathematics Education (TURCOMAT)*, vol. 12, No. 3, pp. 1147-1155, 2021.
- [10] E. Commission, "ec.europa," [Online]. Available: https://ec.europa.eu/info/eu-regional-and-urban-development/topics/cities-and-urban-development/city-initiatives/smart-cities_en.. [Accessed 2021].
- [11] R. K. R. Kummitha, "Smart cities and entrepreneurship: An agenda for future research," *Technological Forecasting and Social Change*, vol. 149, p. 119763, 2019.
- [12] A. M. A. R. F. Al-muqarm, "IoT Technologies for Mobile Crowd Sensing in Smart Cities," *J. Commun.*, vol. 14, pp. 745-757, 2019.
- [13] D. S. S. P. Justyna Winkowska, "Smart city concept in the light of the literature review,"

- Engineering Management in Production and Services*, vol. 11, 2019.
- [14] Delgado, Gerard & Castro Toledo, Francisco, "Urban security and crime prevention in smart cities: a systematic review," 2020, [Online]. Available: osf.io/preprints/socarxiv/7jwtc.
- [15] J. J. P. F. E. Wang, "Elastic urban video surveillance system using edge computing," in *the Workshop on Smart Internet of Things*, 2017.
- [16] "spectrumsmartcities," 3 August 2019. [Online]. Available: <https://spectrumsmartcities.com/what-are-smart-cities/public-safety.html>.
- [17] K. S. B. Prislán, "Analysis of the relationship between smart cities, policing and criminal investigation," *Varstvoslovje*, vol. 20, pp. 389-413, 2018.
- [18] M. K. L. B. G. I. J. S.-M. E. M. d. C. J. J. Y. Tan Yigitcanlar, "Understanding 'smart cities': Intertwining development drivers with desired outcomes in a multidimensional framework," *cities*, vol. 81, pp. 145-160, 2018.
- [19] I. L. A. S. A. K. Y.V. Truntsevsky, "A smart city is a safe city: the current status of street crime and its victim prevention using a digital application," in *International Science Conference SPbWOSCE-2017 "Business Technologies for Sustainable Urban Development"*, 2018.
- [20] H. Z. Jingyi He, "Prediction of crime rate in urban neighborhoods based on machine learning," *Engineering Applications of Artificial Intelligence*, vol. 106, p. 104460, 2021.
- [21] A. N. Y.-H. P. Jeong-Yong Byun, "Internet of things for smart crime detection," *Contemporary Engineering Sciences*, vol. 7, pp. 749 - 754, 2014.
- [22] E. C. D. T. A. V. Charlie Catlett, "A data-driven approach for spatio-temporal crime predictions in smart cities," in *IEEE International Conference on Smart Computing (SMARTCOMP)*, Taormina, Italy, 2018.
- [23] S. L. ., F. H. H. ., A. A. B. T. W. K. a. H. H. R. S. Umair Muneer Butt, "Spatio-temporal crime predictions by leveraging artificial intelligence for citizens security in smart cities," *IEEE Access*, vol. 9, pp. 47516-47529, 2021.
- [24] A. H. S. P. K. Rabia Musheer Aziz, "Machine Learning-based Soft Computing Regression Analysis Approach for Crime Data Prediction," *Karbala International Journal of Modern Science*, vol. 8, pp. 1-19, 2022.
- [25] G. Syswerda, "Uniform Crossover in Genetic Algorithms," in *3rd International Conference on Genetic Algorithms*, Cambridge, 1989.
- [26] Y. S. M. M. N. S. Abid Hussain, "An Efficient Genetic Algorithm for Numerical Function Optimization with Two New Crossover Operators," *International Journal of Mathematical Sciences and Computing*, vol. 4, pp. 1-17, 2018.
- [27] H. L. ., B. F. ., Z. W. ., S. Z. Z. W. Yirui Jiang, "Street Patrol Routing Optimization in Smart City Management Based on Genetic Algorithm: A Case in Zhengzhou, China," *ISPRS International Journal of Geo-Information*, vol. 11, p. 171, 2022.
- [28] F. R. Israa Saeed Ibrahim, "Smart Cities Population Classification Using Hadoop MapReduce," in *Proceedings of Third Doctoral Symposium on Computational Intelligence*, Singapore, 2022.
- [29] M. R. Oraibi and A. M. Radhi, "Enhancement Digital Forensic Approach for Inter-Frame Video Forgery Detection Using a Deep Learning Technique," *Iraqi Journal of Science*, vol. 63, no. 6, pp. 2686–2701, Jun. 2022.
- [30] H. M. Burhan, M. N. Abbas, and B. A. Attea, "A Genetic Algorithm for Task Allocation Problem in the Internet of Things," *Iraqi Journal of Science*, vol. 62, no. 4, pp. 1376–1385, Apr. 2021.
- [31] "knoema," [Online]. Available: <https://knoema.com/>. [Accessed 2021].