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# COMPARISON OF GENETIC ALGORITHM COMPONENTS AND SELECTION VARIANTS IN UNLAWFUL BEHAVIOR DETECTION OF HAND MOVEMENT

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## ABSTRACT

Video Surveillance System (VSS) relies on behavior detection mostly for abnormal or unlawful gestures. Nowadays, the manual detection of unlawful or suspicious behavior through the ongoing advancement of surveillance cameras make it become unfeasible due to the size of the image that need to be scan through. This paper aims to present an unlawful behavior detection of hand movement which apply genetic algorithm (GA) to efficiently determine the validity of the hand movements. An investigation on GA components was performed to determine which component has the strongest impact on the performance. GA selection was identified; tournament selection and random permutation selection were chosen to be experimented. The result demonstrates tournament selection produced better result in terms of the detection rate and false negative rate by using confusion matrix derivation.

**Keywords:** unlawful behaviour; genetic algorithm; tournament selection; random permutation selection.

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## 1. INTRODUCTION

### 1.1. Background

Video surveillance system (VSS) for human has been seen as one of the most active research topics in computer vision and has been applied in many areas such as public transportation, airport, railway station and warfare. The purpose of a VSS is to observe and detect any unlawful behavior occurred in an authorized venue or any area of interest. It helps to prevent and investigating crime and also to ensure individual's privacy, safety and security [1-2]. There are two types of monitoring which are online and offline. For the online VSS, it requires a 24 hours observation by human which leads to misjudging the scene due to the chances of losing focus and alertness. Analyzing VSS for abnormal event requires certain level of behavior understanding. The manual VSS detection is no longer practical since the possibility of crime acts to be foreseen and misinterpreted is very high due to size and load of the images that need to be scan through. The number of Video Surveillance Data (VSD) has increased exponentially which made it increasingly difficult for human to observe all channels continuously, yet it is money and time consuming [2-5].

People's behaviors show diversity in personality, culture, growing-up background, social norms and expectations [6]. Therefore, it is difficult to identify human expressions and movements. Voice quality, body motion, touch, facial expression and the use of personal space are the example of non-language behavior which appears to play a prominent role in communication [7]. Generally, human behavior can be defined as the actions or manners expressed by people or humans. The reflection of human behavior is covered by three major parts of human beings which are mind, body and spirit [8]. Human behavior can also be defined as a collection of activities performed by human beings and influenced by culture, attitudes, emotions, values, ethics, authority, rapport, hypnosis, persuasion and or coercion [9]. In other words, human behavior is simply the actions or reactions made by human beings as a result of influences and events [10]. Human behaviors and natural spatial structures never repeat identically [11].

A basic behavior understanding is considered as one of the crucial elements in developing an automated identification and detection system. It is required in order to analyze and recognize the suspicious motion patterns and to obtain a description towards the actions and interactions

[12-13].

In this paper we proposed an unlawful behavior detection using genetic algorithm (GA). Although GA is a popular efficient stochastic algorithm which has been proven to be a robust problem solving technique [3], identifying which GA component gives the strongest impact on the GA performance add another problem to be addressed. By using two different selection variants which are tournament selection (TOS) and random permutation selection (RPS), the classification of the behavior is then classified into true positive (TP), true negative (TN), false positive (FP) and false negative (FN).

In this paper, a successful effort is performed to detect unlawful behavior and to classify them as TP, TN, FP and FN. The remainders of the paper are formed as follows. Section 2 details out the domain which is unlawful behavior and section 3 describes about the related works regarding suspicious behavior detection. Section 4 described the GA and its components respectively. Section 5 shows the experiment results for both TOS and RPS and represented in the tables, section 6 is the contribution and section 7 is conclusion.

## 2. UNLAWFUL BEHAVIOR

Recently, several research have been developed on detection of unlawful or suspicious behaviors based on sequences taken from surveillance camera. There was some research aimed at recognizing human behaviors such as walking, running, sitting, standing from a single camera which is a basis of recognizing human intention. It is very important to have a significant recognition process of the behavior and it cannot be taken for granted. The examples of dangerous behavior are unlawful entry, forcible entry, stalking and vandalism can be detected from one camera [14].

Unlawful entry requires no force and harmless to people. Existence of objects or people in venues that they are unauthorized to or appear in the location that they are not belong to is considered suspicious. When a person tries to enter a place that is unpermitted, for example an authorized academic building it is considered as a breach towards the tort laws which relates to trespassing regulations [15]. Illegal trespass is about prohibited act performed on one's personal property which leads to breaching peace [16]. The headquarters of the US Army stated that it is performed without force and permission from the owner or an authorized

person, but with intention to steal or fraud which is related to breaking. The intention in committing the offense is not important but the basis evidence for the offense is the entry was unlawful and ones can be accused as guilty. Unlawful entry refers to individuals illegally enter or penetrate on other's property [17]. An illegal action allied to breaking or illegal entering typically engaged with burglary or theft.

## 3. RELATED WORKS

Recently, an increasing number of computer vision research majoring in suspicious behaviour detection have been proposed and developed. Statistical algorithms such as Bayesian Algorithm, Hidden Markov Model (HMM), Latent Dirichlet Allocation (LDA) and incremental outlier detection algorithm were implemented in the field.

### 3.1. Dynamic Bayesian Network

Dynamic Bayesian Network can be used to measure the patterns of the behavior [3, 18]. Spatio-temporal patches are used to formulate the problem of detecting regularities and irregularities. The problem is grouped as an inference process in a probabilistic graphical model. A new graph-based Bayesian inference algorithm was represented. The new presented algorithm allows efficiency in detecting a group of patches at multiple spatio-temporal scales. Regions in image or video sequence can be composed using huge contiguous chunks of data extracted from the database. It consists of a set of visual example. The regions that cannot be composed from the example database are concluded as suspicious. An approach that is capable of identifying a valid behavior in one section and a suspicious one in a different section was proposed. The detection of the suspicious regions is only within the selected frame. Unfortunately, it was stated that class-based representations is not suitable for the task of detecting irregularities since it cannot capture the irresistible number of possibilities of composing irregular behavior [11]. The problem of detecting suspicious behavior from a collection of individual events was addressed [19]. Bayesian framework was established for the purpose of evaluating event traces and the evaluation. They discussed approaches that simplify detection by estimating the conditional probabilities.

### 3.2. Hidden Markov Model (HMM)

A new method for identification of suspicious behavior in video surveillance data using Hidden Markov Model (HMM) was proposed [12]. Scene-specific statistical model was constructed to explain the behavior occurring in a small bootstrap data set. It partition the bootstrap set and assigns new observation sequences to clusters based on statistical tests of HMM log likelihood scores. HMM was evaluated with the aid of configuration selection and anomaly detection. Anomaly detection used three methods for experimental purpose which are k-Nearest Neighbor, Principal Component Analysis (PCA) and Support Vector Machine (SVM). The best result obtained is using SVM since it achieves a hit rate of 100%. SVM can successfully solved pattern classification problem by maximizing margin of the linear decision boundary of the movements to achieve the maximum separation of the subject classes [20]. Unfortunately, HMM with SVM may suffer from lower accuracy if it is being applied in another scenario and not suitable for long sequences of data such as video recordings [3]. The model structure chosen is based on previous empirical experience.

## 4. GENETIC ALGORITHM (GA)

GA is a bio-inspired search method based on principles of natural selection and genetics [21]. GA is a powerful general purpose optimization tools which are competent in discovering the optimal solution in most of the complex search spaces. They rely on a population of coded solutions which are selected according to their quality and then used as the basis for a new generation of solutions found by crossover or mutating the current individuals using direct search. A greater number chromosome gives a better solution. Traditionally, the search mechanism has been domain independent. In other words, the crossover and mutation operators have no knowledge of what a good solution would be. GA uses a simple and direct representation of characteristic of the domain [22].

The methodology of GA involves different steps and phases which differ from the process of natural evolution such as population, competition and selection and reproduction of the individuals in the population. The factors which lead to the effectiveness of the algorithm have to be measured thoroughly. Those factors include the chromosome representation issues, population size, maximum generations, choice of operators and its rates [23-24].

Genetic algorithm was successfully applied in computer network intrusion detection system for different scenarios [11, 25]. The function of GA is to choose required features and represent it as an individual to determine the optimal and minimal solution of the problem. IDS was used to detect unlawful network behavior [25-29], thus contributed to implement it in physical unlawful detection by using GA to solve the problem.

### 4.1.Genetic Algorithm Components

GA has the ability in finding global optima while being able to cope with discontinuous and noisy functions [30]. Therefore, it is proven to be a powerful optimization technique and has been successfully deployed in different area of studies [31]. There are various variations of GA such as Compact GA (CGA) [32] and Adaptive Probability GA [33] that modifies the basic operation of GA to improve the algorithm. Even a simple GA is able to solve to optimize difficult types of problems such as computer-based intrusion detection system [3, 25]. Table 1 illustrates the comparison of the GA components.

**Table 1.** GA components and the effects on performance

| Component | How Does it Affect the Performance? |
|---|---|
| Population | • A small population size initialization should be avoided because it can cause premature convergence [34].<br>• The greater the population size, the more solution that can be obtained. It is the major factor that affects the performance of GA [34-35]. |
| Fitness Evaluation | • Determine the fitness of the individuals and determine the fittest and the worse [36].<br>• The performance of the fitness function is dependent to the problem [36].<br>• Fitness function may generate bad blocks of chromosomes [36]. |
| Selection | • Selection operator worked using the information obtained during the adaptive process of looking for solution [37].<br>• The selection operator is carefully formulated to ensure that |

| | |
|---|---|
| | better members of the (with higher fitness) have a greater probability of being selected for mating whereas but that worse members of the population still have a small probability of being selected [38].<br>• This is important to ensure that the search process is global and does not simply converge to the nearest local optimum [38]. |
| Reproduction | |
| i) Crossover | • There are many types of crossover such as one-point crossover, two-point crossover, uniform crossover and asexual crossover [36].<br>• It is dependent to user on choosing crossover type but if the function returns nil, there will be no mating process [36]. |
| ii) Mutation | • Similar to crossover, there are several types of mutation such as population based mutation, one point mutation or value based mutation [36].<br>• It is dependent to user on choosing crossover type but if the function returns nil, there will be no mating process [36]. |

From the components illustrated in Table 1, GA selection was chosen to be compared as it does affect the overall performance of the GA [12, 36, 39]. Although population size is said to be the major factor affecting the performance of GA, but if an ideal population size is set and maintain on the problem domain, no premature convergence will occur [35, 40]. On the other hand, fitness evaluation does not have enough influence since the selection operator may select the weakest individual for mating. In addition, selection is believed to be overly exploitative on the theoretical analysis of convergence time [41-42]. It involved selecting individuals based on their fitness. The best individuals may not guarantee better result, but yet a good solution can be obtained although the individual is the weakest in the population. There might be a probability of no mating process in a population and the final result will be based on the population selected by the selection method resulting in affecting the performance of the GA. Thus, from the above reasons, this paper proposed two types of

selection operator to efficiently identify and detect the unlawful behavior.

### 4.2.Chromosome Representation

The vector values of x and y was returned from the bounding box of the blob/gesture analysis of the hand movement and the Euclidean distance (ED) of the vectors in every frame is calculated. This was executed during the image processing phase. Then, the three attributes were combined to become a single chromosome. The genes will then determine the fitness of the chromosome with a random weight value. The chromosome is illustrated in Fig. 1.

| Vector x | Vector y | ED |
|---|---|---|

**Fig.1.** Chromosome representation

#### 4.2.1. Vector x and y

In order to get the required region of the hand, the center of the mass of the foreground region was automatically identified by the centroid properties performed by MATLAB regionprops function. Then, the points of the foreground target is grouped using bounding foreground box and labelled as vector x and y. The points are represented in '*'. Fig. 2 shows the sample of getting the required region.

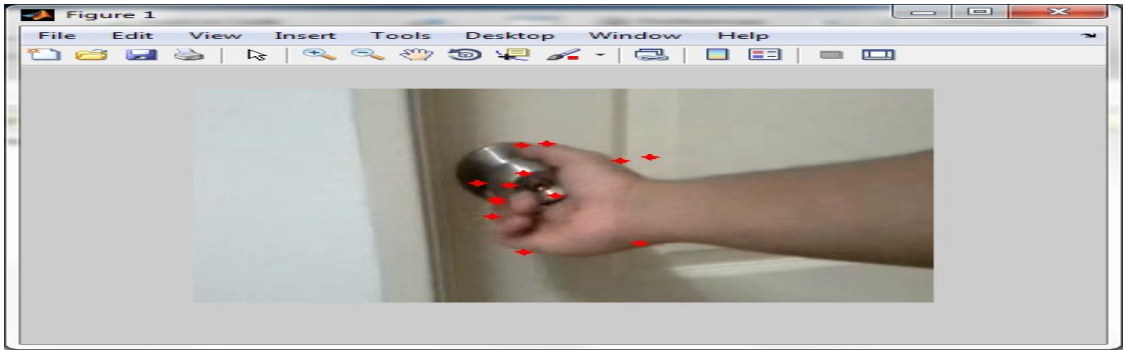


**Fig.2.** To get the region

#### 4.2.2. Euclidean Distance (ED)

ED equation is being applied to detect a transition of the hand movements from one point to another throughout the entire video recording. The default ED applied is:

$$||y - x|| = \sqrt{||x||^2 + ||y||^2 - 2x \,.\, y}$$

x and y is a one dimensional vector and is called a displacement vector. Thus, the ED of the point x and y is actually the Euclidean length of the displacement vector.

### 4.3. Selection

The first step is selecting individuals for reproduction after the initial population is created. To

generate good offspring, a selection of parents needs to be performed before crossover. Selection of the chromosome can be done using several types of selection scheme such as proportional, ranking, tournament and random permutation [38, 41-42].

However, two types of selection variants selected to be experimented in this paper are Tournament Selection (TOS) and Random Permutation Selection (RPS).

1) Tournament Selection (TOS): TOS involves choosing two individuals of the population and organizes tournaments to determine which one is picked. TOS is a variant of rank-based selection methods. Its principle consists in randomly selecting a set ofindividuals. These individuals are then ranked according to their relative fitness and the fittest individual is selected for reproduction. The whole process is repeated times for the entire population [25].
2) Random Permutation Selection (RPS):RPS is about randomly selecting an object from its ordering. Although random permutation is a very simple selection method, it does affect the performance of a GA [29, 43]. Random permutation has a high probability in choosing the weakest chromosome rather than the fittest one for mating, thus affecting the overall performance of the GA.

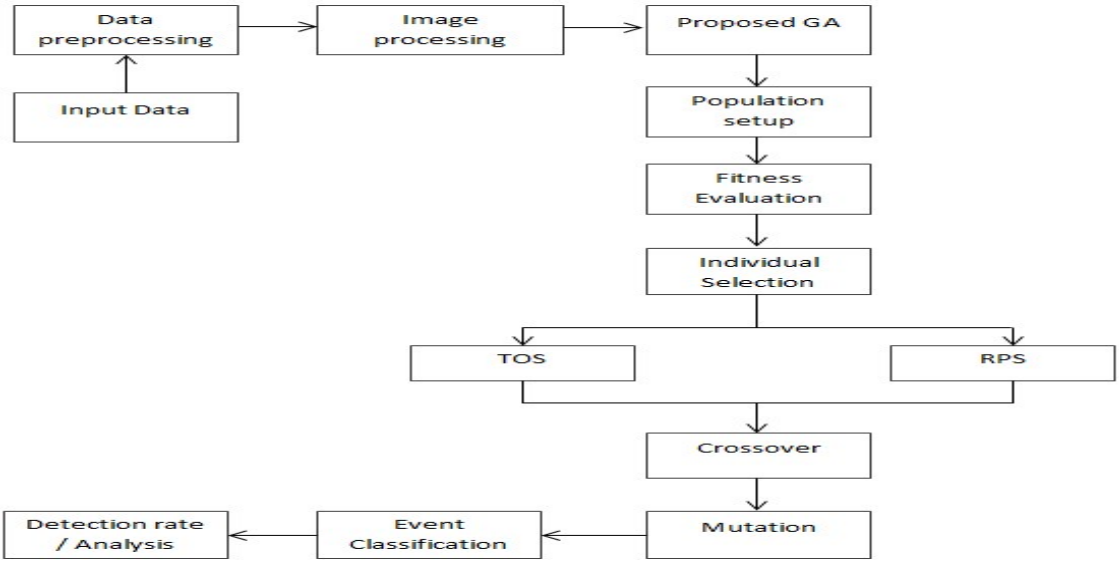


**Fig.3.** Proposed architecture

From Fig. 3, the method has been proposed in a way that it will do analysis on the event classification to get to the validity of the hand gesture. The ED of each frame in the video data

is calculated to match with the fixed threshold value of the behaviour pattern performed during the training phase.

## 5. EXPERIMENTAL RESULTS

Total data of 95 videos regarding hand movements were collected through KTH dataset, Weizmann dataset and hand dataset, online and offline. The datasets contained different hand gestures or movements of door knocking, knob twisting, hand waving and handclapping. An initial population of the 100 chromosomes and maximum iteration of 100 is generated. Fitness evaluation is important to determine the opportunity or chances of being selected for reproduction. The fitness function applied is as equation:

$$f(x) = \sum_{i=0}^{n} |\text{gene(i)} * \text{w(i)}|$$

where n = number of iteration, gene = individual in the population and w = random weight.

The individuals are then being selected using TOS and RPS respectively for reproduction (crossover and mutation). Two-point crossover with probability of 0.9 and value encoding mutation with probability of 0.2 was implemented to acquire new offspring for a new population. For event classification, ED in every frame is taken into consideration to ensure it is within the fixed threshold range of lawful pattern. If it exceeds the range, then the event is considered as unlawful. In order to evaluation of the performance of the detection, it is illustrated using the confusion matrix [44] as in Table 2.

**Table 2.** Confusion matrix

| Test | Positive (Lawful) | Negative (Unlawful) |
|---|---|---|
| Positive (Lawful) | True Positive (TP) | False Negative (FN) |
| Negative (Unlawful) | False Positive (FP) | True Negative (TN) |

**Table 3.** Confusion matrix for TOS and RPS

| | Total (P+N) | TP | FN | FP | TN |
|---|---|---|---|---|---|
| TOS | 95 | 73 | 1 | 10 | 11 |
| RPS | 95 | 67 | 5 | 12 | 11 |

Out of the 95 recordings, 73 videos classified as TP (correctly identified as lawful), 11 videos of TN (correctly identified as unlawful), 10 videos of FP (incorrectly identified as lawful) and

one video of FN (incorrectly identified as unlawful) for TOS whereas for RPS, 67 videos were classified as TP, 11 videos of TN, 12 videos of FP and five videos of FN. It has been identified that TOS performed better than RPS since it achieved a higher TP value than RPS. In addition, TOS produced a lower FN value which is only one case was incorrectly detected as unlawful, compared to RPS that is five cases. The derivation of confusion matrix for both selection variants is depicted in Table 4.

**Table 4.** Comparison of detection result

| | **TOS** | **RPS** |
|---|---|---|
| Detection Rate (DR) | 0.9865 | 0.931 |
| False Negative Rate (FNR) | 0.0135 | 0.0694 |

From Table 4, it is identified that TOS achieved a gap of 1.3% towards the DR/sensitivity whereas RPS having a gap of 6.9%. This proved that TOS give better DR and a better FNR value compare to RPS.

## 6. CONTRIBUTION

This research put a new contribution on the representing the information (vector x, vector y and ED) obtained from the foreground bounding box properties on the target as a GA chromosome. Therefore, this contribution is proved to be very crucial in order to design the GA for detection process. Another contribution is comparing the effect of each GA components which are the population size, fitness evaluation, selection and reproduction on GA performance. Despite some work has been done on suspicious behavior detection, most of them focused only on the detection result rather than how much the algorithm components affect the performance of the algorithm itself. Another thing to be addressed is performance of different GA selection variants; TOS and RPS were compared to find out which variant performs better.

## 7. CONCLUSION

This paper presents and implemented an unlawful behavior detection system by adapting genetic algorithm (GA) [45] to efficiently detect the unlawful hand movement, which may lead to unlawful entry. To measure the performance of the system, the confusion matrix derivation of the system for both GA TOS and RPS was calculated. With a better DR and

FNR, GA with TOS yield better result than GA with RPS. In the future, it is recommended that more bio-inspired algorithms are to be used in the suspicious detection system due to its promising history and performance in various areas to support GA algorithm in this research. Utilizing the enhanced version of GA could also contribute to even more possibilities towards problem solving. Theoretically, different selection variants show different result on the detection rate and false negative rate and provide a potential where an optimal solution can be found. However, the execution of the algorithm will not have problem if a suitable selection variant is chosen. In fact, the other available selection variant such as roulette wheel and other components of GA such as population size can be recommended to be adjusted, implemented and compared. On the other hand, it is also suggested to expand the scope of action or parameters by combining different hand movement or different body parts together in a video sequence. By combining different movement, it may give a different angle of value of the detection.

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