World Academy of Science, Engineering and Technology
International Journal of Computer and Information Engineering
Vol:16, No:10, 2022

Automatic Detection of Suicidal Behaviors Using an RGB-D Camera: Azure Kinect

Maha Jazouli

***Abstract*—**Suicide is one of the leading causes of death among prisoners, both in Canada and internationally. In recent years, rates of attempts of suicide and self-harm suicide have increased, with hangings being the most frequently used method. The objective of this article is to propose a method to automatically detect suicidal behaviors in real time. We present a gesture recognition system that consists of three modules: model-based movement tracking, feature extraction, and gesture recognition using machine learning algorithms (MLA). Tests show that the proposed system gives satisfactory results. This smart video surveillance system can help assist staff responsible for the safety and health of inmates by alerting them when suicidal behavior is detected, which helps reduce mortality rates and save lives.

***Keywords*—**Suicide detection, Kinect Azure, RGB-D camera, SVM, gesture recognition.

I. Introduction

SUICIDE attempts are one of the main problems faced by correctional services worldwide. Even beyond the prison environment, such attempts represent a growing concern. Every year, a total of about 25 million attempts are recorded according to the Center for Disease Control and Prevention, the World Health Organization [1]. To address this problem, various technologies have been proposed to detect indicators that can be used for prevention.

The main objective of this article is to design and develop an intelligent system for the monitoring of life signs and behavioral patterns of prison inmates with built-in detection capability for attempts of suicide and self-harm.

Methodically, the paper is divided into five sections. In Section II, we will review the previous work on automatic recognition of gestures using RGB-camera. While proposed solutions for implementing the proposed method appear in Section III, experiment results aimed at evaluating the efficiency and the robustness of our system will be the focus of Section IV. We conclude the paper in Section V.

II. Related Works

The medical sector offers more and more technical solutions based on the digital acquisition of video sequences. The clinical psychology area is focused on the detection and analysis of human behavior through computer vision.

Recognizing behaviors and predicting people's activities from video are major concerns in the field of computer vision. Dang et al. [2] present an interesting survey on human activity recognition (HAR) methods, which are divided into two groups: sensor-based HAR and vision-based HAR. Furthermore, activity recognition systems are more and more interested in activity recognition based on skeletal data. Ashwini and Amutha [3] propose an activity recognition system using a Kinect sensor. The general contribution of their work is in recognizing human activities using Kinect and machine learning algorithms. The proposed method is tested on the most popular KARD (Kinect Activity Recognition Dataset) and an SVM (Support Vector Machine) classifier is used to classify the dataset. The Microsoft Kinect sensor has become very popular for its effortless operation and low cost.

In this work, our goal is to set up an intelligent video surveillance system that can help detect in real time the suicidal behavior of prisoners. Some technologies have been developed to detect suicides based on artificial intelligence. The use of machine learning can help reduce the incidence of death by suicide. On the one hand, most recent work is interested in the detection of suicide prevention based on a patient's psychological record [4]-[8]. On the other hand, studies have been done on the detection of suicidal behavior based on sensors [7], [8]. In the literature, we find few works that address the issue of recognizing suicidal behavior in real time.

Graichen et al. [9] were one of the first groups to propose a monitoring system capable of identifying suicide attempts. The authors proposed a wall-mounted system that could continuously track the heart rate, respiration, and movements of the inmates with alarm functionality. The proposed system consisted of an off-the-shelf Doppler radar used for home security and modified to detect chest movements. Convulsions and a slowing rate of the heart were proposed to be indicative of asphyxiation. However, the system was not automated and therefore required user intervention for operation, which was claimed to have 86% precision.

Lee et al. [10] propose a system to detect and prevent hanging attempts. Their approach is based on a 3D camera being used to identify the behavior. By using a random forest classifier, their system can detect hanging suicide attempts with more than 95% accuracy.

Chiranjeevi and Elangovan [11] present a system based on a deep learning concept with the help of self-organized mapping, which is used to extract features after videos are captured from surveillance cameras. This proposed system will provide more efficient results in predicting hanging attempts when compared to the traditional methods.

Bouachir et al. [12], [13] present a system for detecting suicide attempts by hanging in prisons. Their approach is based

Maha Jazouli is with Cilex, Language Technology Research Center, Canada (e-mail: maha.jazouli@cilex.ca).

on modeling suicidal actions through pose and motion features. They propose a computer vision system using depth images provided by an RGB-D camera (Kinect V2) to identify the 3D locations of joints. Their system presents a binary classification on a single observation of "suicide" or "unsuspected" behavior based on an LDA (Linear Discriminant Analysis) classifier [14], [15].

De Boissière [16] presents, in his thesis work, a study on behaviors and potentially deadly events in prison using video analysis. He proposes a method of HAR by artificial intelligence based on a deep learning architecture, combining infrared video with 3D pose data. He evaluates the performances of his model on the NTU RGB+D and PKU-MMD datasets.

We can summarize that, a suicidal behaviors system can be divided into three stages: (i) monitoring and gesture detection, (ii) gesture feature extraction, and (iii) gesture classification. This article is interested to automatically detect five suicidal behaviors: hand to neck standing, hand to neck sitting, self-cut standing, self-cut sitting, standing on chair with hand to neck in real time by proposing a method that gives good results.

III. Proposed Approach

The objective of this work is to recognize and monitor the behavior of self-stimulation observed by imprisoned persons. The proposed system presents a methodology to automatically detect five suicidal behaviors: hand to neck sitting, hand to neck standing, self-cut sitting, self-cut standing, standing on a chair. We propose to automatically detect suicide in real-time using the Azure Kinect sensor.

We present a gesture recognition system, which consists of three modules: model-based gesture tracking, feature extraction, and gesture recognition using MLA (Fig. 4). The first one uses three Azure Kinect sensors, the second one chooses points of interest from the 3D skeleton to characterize the gestures, and the last one proposes different MLA for classification of data.

The proposed project aims to combine parameters from three different sensors of the Kinect Azure camera, in order to detect and recognize suicidal gestures.

A. Extraction Features

In order to acquire motion data, in this research, we use 3D skeleton model information generated from the Azure Kinect sensor, as in Fig. 1. The position and orientation of each joint forms its own joint coordinate system. All joint coordinate systems are absolute coordinate systems relative to the depth camera 3D coordinate system.

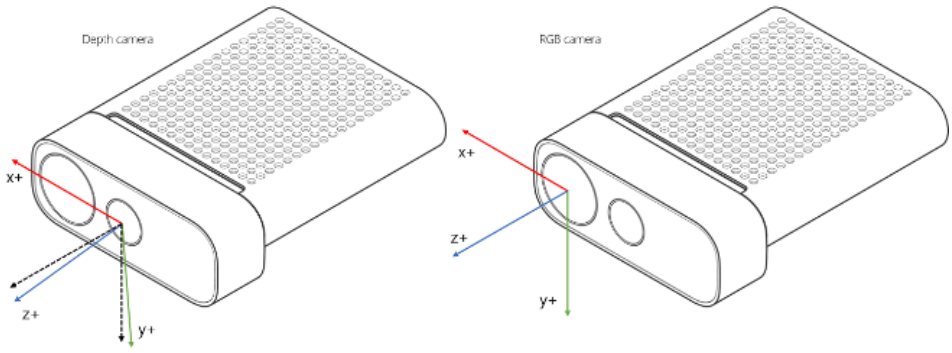

Fig. 1 Azure Kinect Sensor

TABLE I
The Desired Output Vector for Each of the 5 Classes

Class	Denomination	Desired outputs
1	hand to neck sitting	(1, 0, 0, 0,0)
2	hand to neck standing	(0, 1, 0, 0,0)
3	self-cut sitting	(0, 0, 1, 0, 0)
4	self-cut standing	(0, 0, 0, 1, 0)
5	standing on a chair	(0, 0, 0, 0, 1)

The raw data taken from the Azure Kinect sensor correspond to the X, Y and Z coordinates of the joints. Microsoft provides an SDK with the Azure Kinect (API) allowing easy access to skeletal joints. The SDK supports the tracking of up to 32 joint points. Each gesture is characterized by a sequence of joints movements (Fig. 3) [17], [18].

We have built our own dataset because there are no publicly available datasets for suicidal gestures. It consists of 10 individuals imitating the selected suicidal gestures: hand to neck sitting, hand to neck standing, self-cut sitting, self-cut standing, standing on a chair. Each person was asked to make each gesture 10 times, which gives us a database of 500 gestures. The data were then divided into 70% for the learning phase and 30% for the test.

B. Machine Learning for Gesture Recognition

The proposed system was tested with several MLA: AdaBroost (Adaptive Boosting), SVM, and DT (Decision Trees). The experimental results show that our system can achieve above 93.9% recognition rate. The best results are obtained by the SVM algorithm (Table II).

Fig. 5 presents the obtained recognition rates in real time using the SVM algorithm to classify each gesture: hand to neck sitting, hand to neck standing, self-cut sitting, self-cut standing, standing on a chair (Fig. 6).

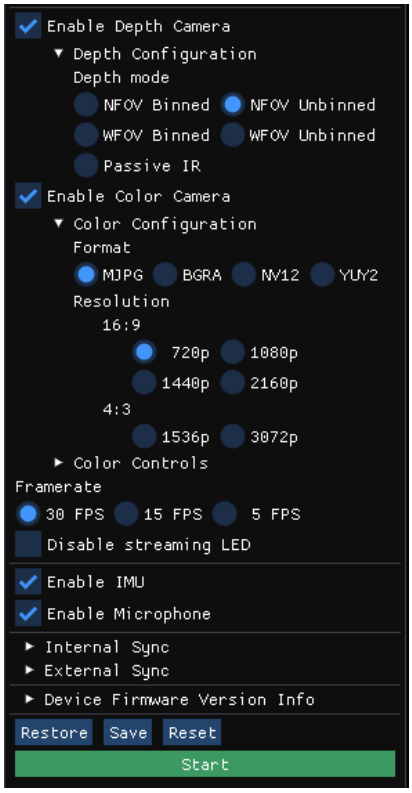

Fig. 2 Azure Kinect Viewer

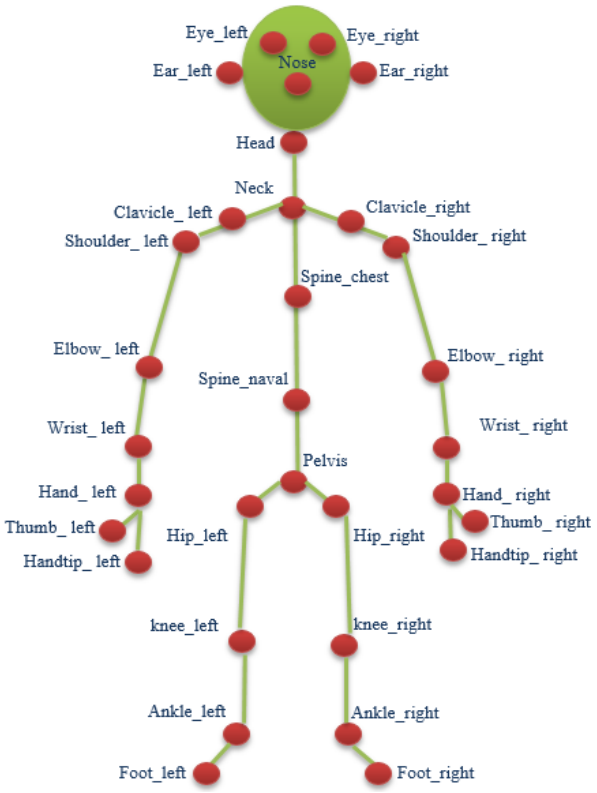

Fig. 3 Points tracked by the Azure Kinect sensor.

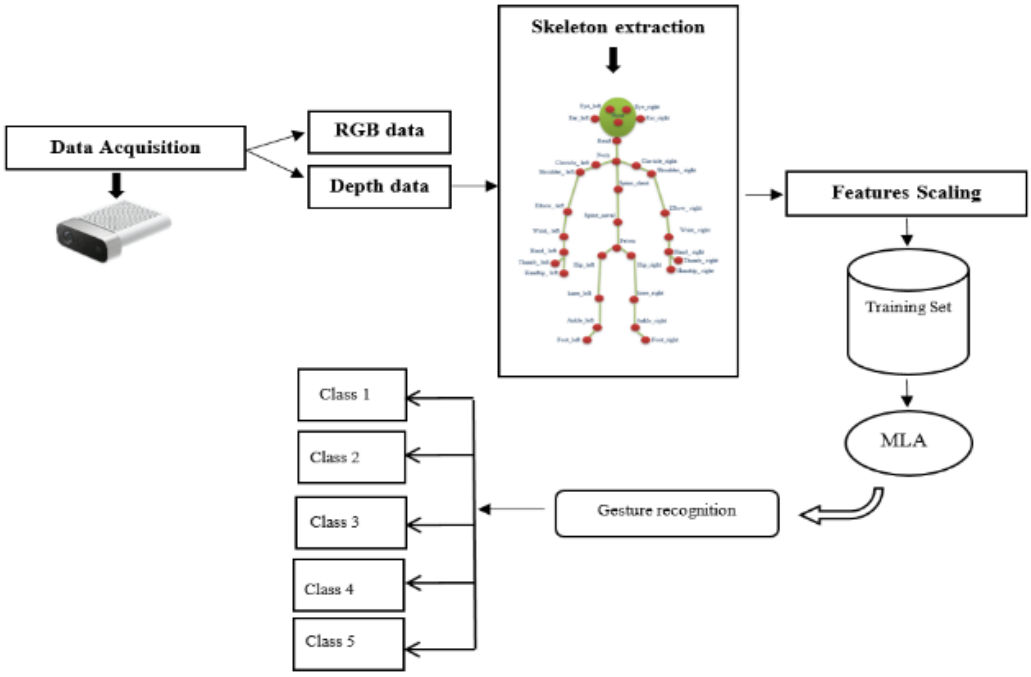

Fig. 4. Global architecture of our system

TABLE II
CLASSIFICATION RATES FOR FIVE SUICIDAL GESTURES OF DIFFERENT MLA

	AdaBoost	SVM	DT
Rate of recognition	85.8%	93.9%	80.4%

IV. CONCLUSIONS

In this paper, we have proposed an approach to detect suicidal behaviors in real time using three Kinect Azure sensors and MLA algorithms. The system recognizes in real time five suicidal gestures: hand to neck sitting, hand to neck standing,

self-cut sitting, self-cut standing, standing on a chair. The system detects 93.9% of the suicidal gestures, which are satisfactory results compared to the literature.

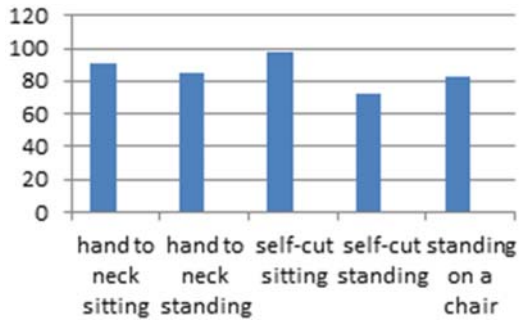

Fig. 5 Classification rates in real time using SVM algorithm to classify each gesture

TABLE III
CONFUSION MATRIX USING SVM ALGORITHM

Class	1	2	3	4	5	Error Rate
1	30 20.0%	0 0.0%	3 2.0%	0 0.0%	0 0.0%	90.90% 9.1%
2	0 0.0%	32 21.33%	0 0.0%	1 0.66%	1 0.66%	94.11% 5.89%
3	3 2.0%	0 0.0%	24 16.0%	0 0.0%	0 0.0%	88.88% 11.12%
4	0 0.0%	1 0.66%	0 0.0%	33 22.0%	0 0.0%	97.05% 2.95%
5	0 0.0%	0 0.0%	0 0.0%	0 0.0%	22 14.66%	100% 0.0%
Error Rate	90.90% 9.1%	96.96% 3.04%	88.88% 11.12%	97.05% 2.95%	95.65% 4.35%	93.9% 2.5%

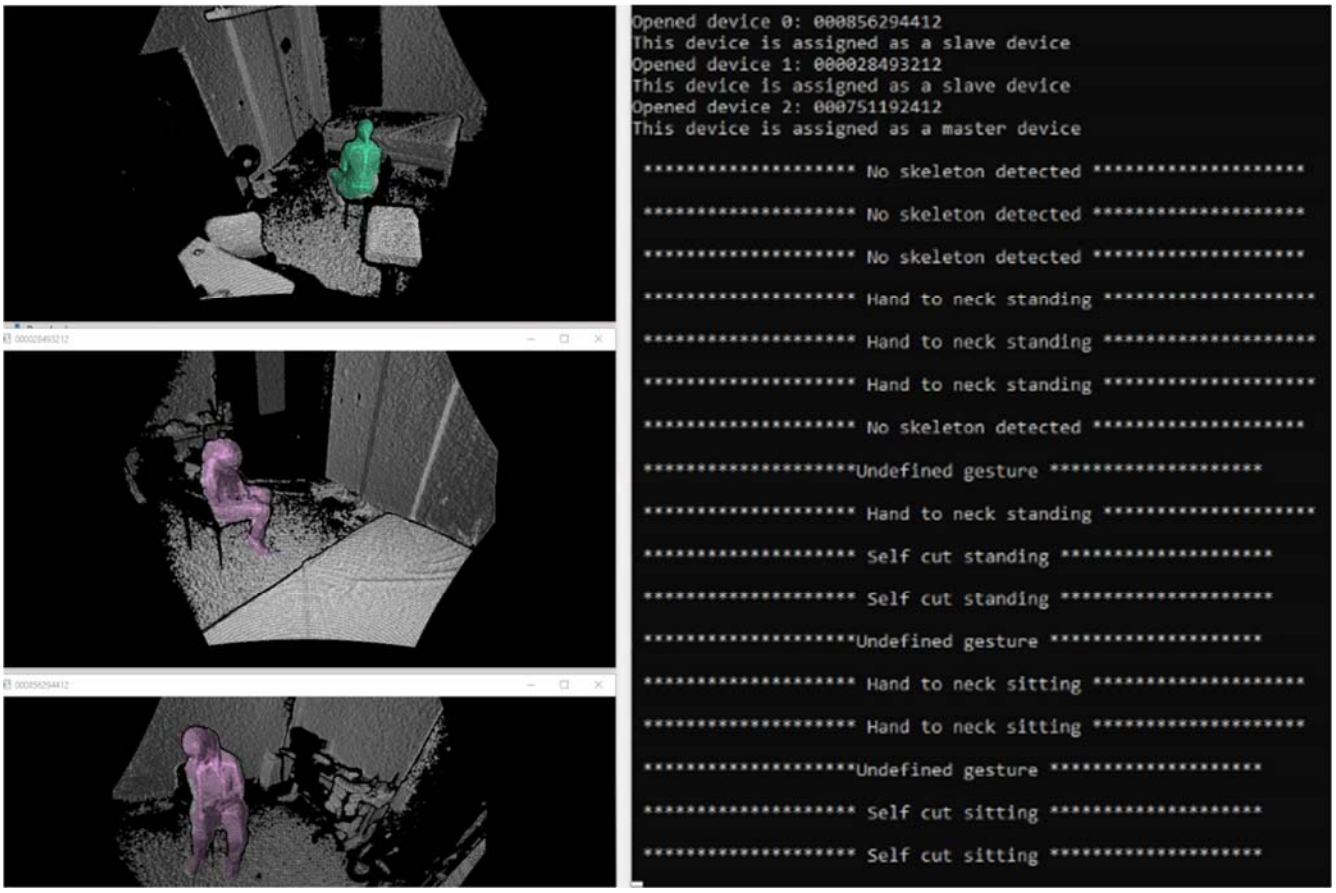

Fig. 6 Gesture classification in real time

For future work, it is important to recognize that the detection rate of false positives and false negatives is critical to ensuring system reliability and performance. In particular, the goal of achieving a low or zero rate for false negatives is paramount for the safety of inmates as well as the uptake of the system by potential users. Also, we consider that is necessary to build a bigger database with different ages and ethnicities of people and we need an exhaustive analysis of suicidal gestures.

ACKNOWLEDGMENTS

The author would like to thank all the people who participated in the creation of a database of suicidal gestures for the realization of this project.

REFERENCES

[1] World Health Organization. (2019). Suicide in the world: global health estimates (No. WHO/MSD/MER/19.3). World Health Organization.
[2] Dang, L. M., Min, K., Wang, H., Piran, M. J., Lee, C. H., & Moon, H.

(2020). Sensor-based and vision-based human activity recognition: A comprehensive survey. Pattern Recognition, 108, 107561.
[3] Ashwini, K., & Amutha, R. (2020, July). Skeletal Data based Activity Recognition System. In 2020 International Conference on Communication and Signal Processing (ICCSP) (pp. 444-447). IEEE.
[4] Walsh, C. G., Ribeiro, J. D., & Franklin, J. C. (2017). Predicting risk of suicide attempts over time through machine learning. Clinical Psychological Science, 5(3), 457-469.
[5] Pestian, J. P., Sorter, M., Connolly, B., Bretonnel Cohen, K., McCullumsmith, C., Gee, J. T., ... & STM Research Group. (2017). A machine learning approach to identifying the thought markers of suicidal subjects: a prospective multicenter trial. Suicide and Life-Threatening Behavior, 47(1), 112-121.
[6] Walsh, C. G., Ribeiro, J. D., & Franklin, J. C. (2018). Predicting suicide attempts in adolescents with longitudinal clinical data and machine learning. Journal of child psychology and psychiatry, 59(12), 1261-1270.
[7] Torous, J., Larsen, M. E., Depp, C., Cosco, T. D., Barnett, I., Nock, M. K., & Firth, J. (2018). Smartphones, sensors, and machine learning to advance real-time prediction and interventions for suicide prevention: a review of current progress and next steps. Current psychiatry reports, 20(7), 51.
[8] Bernert, R. A., Hilberg, A. M., Melia, R., Kim, J. P., Shah, N. H., & Abnousi, F. (2020). Artificial intelligence and suicide prevention: a systematic review of machine learning investigations. International journal of environmental research and public health, 17(16), 5929.
[9] Graichen, C., Ashe, J., Ganesh, M., & Yu, L. (2012, December). Unobtrusive vital signs monitoring with range-controlled radar. In 2012 IEEE Signal Processing in Medicine and Biology Symposium (SPMB) (pp. 1-6). IEEE.
[10] Lee, S., Kim, H., Lee, S., Kim, Y., Lee, D., Ju, J., & Myung, H. (2014). Detection of a suicide by hanging based on a 3-D image analysis. IEEE sensors journal, 14(9), 2934-2935
[11] Chiranjeevi, V. R., & Elangovan, D. (2019, March). Surveillance Based Suicide Detection System Using Deep Learning. In 2019 International Conference on Vision Towards Emerging Trends in Communication and Networking (ViTECoN) (pp. 1-7). IEEE.
[12] Elforaici, M. E. A., Chaaraoui, I., Bouachir, W., Ouakrim, Y., & Mezghani, N. (2018). Posture recognition using an RGB-D camera: exploring 3D body modeling and deep learning approaches. In 2018 IEEE life sciences conference (LSC) (pp. 69-72). IEEE.
[13] Bouachir, W., Gouiaa, R., Li, B., & Noumeir, R. (2018). Intelligent video surveillance for real-time detection of suicide attempts. Pattern Recognition Letters, 110, 1-7.
[14] Li, B., Bouachir, W., Gouiaa, R., & Noumeir, R. (2017). Real-time recognition of suicidal behavior using an RGB-D camera. In 2017 Seventh International Conference on Image Processing Theory, Tools and Applications (IPTA) (pp. 1-6). IEEE.
[15] Bouachir, W., & Noumeir, R. (2016). Automated video surveillance for preventing suicide attempts.
[16] Main de Boissière, A. (2020). Détection de comportements et d'événements potentiellement mortels dans les prisons à partir d'analyse de vidéos par intelligence artificielle (Doctoral dissertation, École de technologie supérieure).
[17] Microsoft Azure Kinect DK documentation: https://docs.microsoft.com/en-us/azure/kinect-dk/,2020
[18] Azure Kinect hardware specification:
[19] https://docs.microsoft.com/en-us/azure/kinect- dk/hardware-specification, 2020