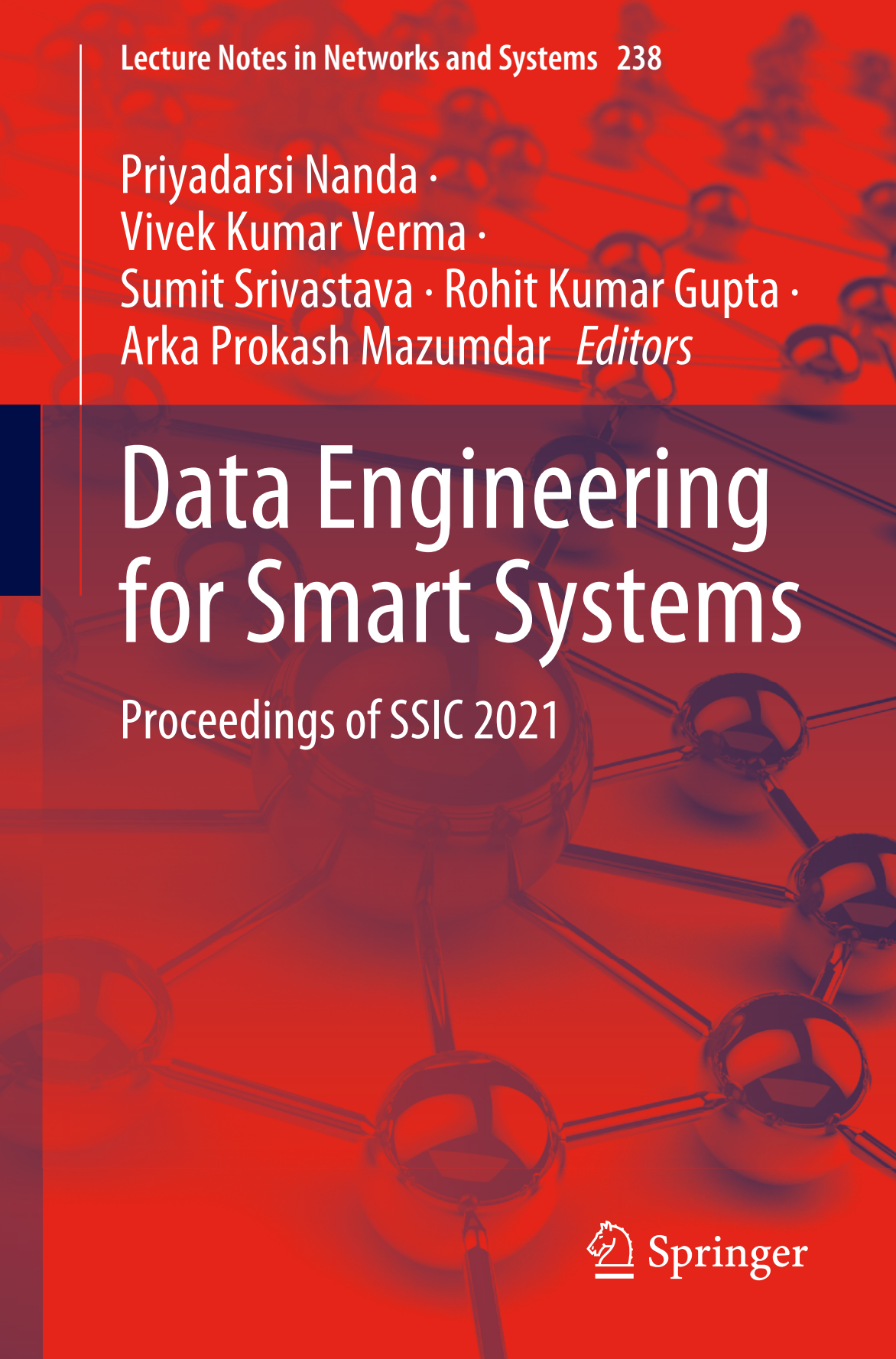
Lecture Notes in Networks and Systems 238

Priyadarsi Nanda ·
Vivek Kumar Verma ·
Sumit Srivastava · Rohit Kumar Gupta ·
Arka Prokash Mazumdar *Editors*

Data Engineering for Smart Systems

Proceedings of SSIC 2021



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Preface

This book is one-pot solution for authors to showcase their work among the research communities, application warehouses and the public–private sectors. This series is an opportunity to gather research scientific works related to data engineering concept in the context of computational intelligence consisted of interaction between smart devices, smart environments and smart interactions, as well as information technology support for such areas. Data from mentioned areas also need to be stored (after their gathering) in intelligent database systems and to be processed (using smart and intelligent approach). The aim of this series is to make available a platform for the publication of books on all aspects of single- and multi-disciplinary research on these themes to make the latest results available in a readily accessible form. The innovations provide the latest software tools to be showcased in the book series through publications. The high-quality content with broad range of the topics pertaining to the book series will be peer-reviewed and get published on suitable recommendations.

This book will provide state of the art to research scholars, scientists, industry learners and postgraduates from the various domains of engineering and related fields, as this incorporates data science and the latest innovations in the field of engineering with their paradigms and methods that employ knowledge and intelligence in the research community. This book comprises its scope ranging from data science for smart systems which are having inbuilt capabilities of handling the research challenges and problems related to energy-aware sensors, smart city projects, wearable devices, smart healthcare solutions, smart e-learning initiatives and social implications of IoT. Further, it extends its coverage to the different computational aspects involved in various domains of engineering such as complex security solutions for data engineering, communication networks, data analytics, machine learning, integrating IoT data with external data sources and data science approaches for smart systems.

Secondarily, this book provides the technological solutions to non-engineering and sciences domain as it contains the fundamental innovation in the field of engineering which turns to be a real solution for their problems. Also, it includes the

paradigms which support industries for the development of solutions in favor of society and make everyone's life easier.

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Using Machine Learning, Image Processing and Neural Networks to Sense Bullying in K-12 Schools: Enhanced

Lalit Kumar, Palash Goyal, Karan Malik, Rishav Kumar, and Dhruv Shrivastav

Abstract We all have heard about bullying, and we know that it is an immense challenge that schools have to tackle. Many lives have been ruined due to bullying, and the fear it implants into students' mind has caused many of them to go into depression which can lead to suicide. Traditional methods (National Academies of Sciences, Engineering, and Medicine, in Preventing bullying through science, policy, and practice. The National Academies Press, Washington, DC, [1]) need to be accompanied with modern technology to make the method more effective and efficient. If real-time alerts are sent to school staff, they can identify the perpetuator and extricate the victim swiftly. In this proposed method, an AI-based solution is implemented to monitor students using standard school surveillance technologies and CCTV to maintain a decorum and safe environment in the school premise. Also the proposed method utilizes other unstructured sources such as attendance records, social media activity and general nature of the students to deliver quick response. Artificial intelligence (AI) techniques like convolutional neural networks (CNNs), which include image-processing capabilities, logistic regression methods, long short-term memory (LSTM) and pre-trained model Darknet-19 are used for classification. Further, the model also included sentiment analysis to identify commonly used abuse terms and noisy labels to improve overall model accuracy. The model has been trained and validated with the realistic data from all the sources mentioned and has achieved the classification accuracy of 87% for detecting any sign of bullying.

Keywords AI · CNN · Class entropy loss · Data-pre-processing · Data pipeline · Facial recognition · NLP · NN · Sigmoid · Sentiment analysis · LSTM · Darknet-19

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1 Introduction

What is bullying? For starters, bullying is aggressive behavior among teenagers. This comes from many factors which involve ego, power imbalance, upbringing, etc. This behavior has no bounds and can impact a victim's physical and mental health conditions. Bullying can take many forms from verbal to physical. With the introduction of social media, social bullying, a new type of bullying which involves harming one's reputation or relationships, has sprung up. A study was conducted by Symantec Reports with the help of parents of many victims. They noted that almost 24% of the students were involved in some shape or form of bullying [2]. Despite such a high percentage of victims, most methods to keep bullying in check have not borne any fruit and mitigation against bullying remains an enigma.

The traditional methods with their limited use of technology are proved not be very effective. It is time to integrate modern technology to develop more intelligent solutions. The proposed method in this paper will use specific elements of AI tools which exploit the already-available school infrastructure to make it a new means of keeping taps on bullying.

2 Methodology of Research and Solution Development

First of all, we have identified all the physical, mental, emotional, social and cyberbullying types and parameters that are prevalent. For this, extensive study of existing literature has been done [1–3]. Subsequently, these parameters were studied to identify how they can be objectively analyzed. This involved identifying the data sources that can give input signals for that bullying parameter. Once the data sources were identified, actual data was recovered from these sources. Again, existing literature was studied [4–7] extensively to identify AI/ML algorithms that can be used to classify them with binary outputs linked to whether this is a bullying situation or not. In case bullying is detected, our system detects and recognizes faces of those involved and sends real-time alerts to the authorities, with the identity of the perpetrator [8, 9]. The authors then put together all these elements to develop a working model of their solution with a proof of concept done in a school. The research methodology followed in this is as given below in Fig. 1.

2.1 Bullying Parameters/Features

To identify the signs of bullying, we have taken multiple parameters under consideration through which we can filter-out real bullies from other behaviors which could be mistaken for bullying. Features like rude behavior, troubling authorities regularly, low attendance, use of foul language, low scores, drug use, explicit content, etc.

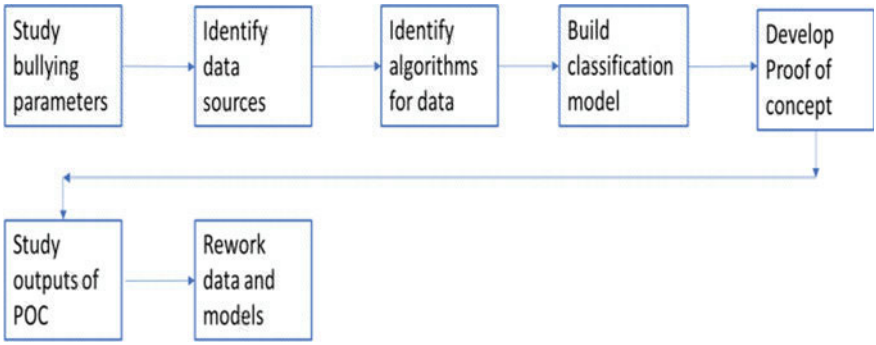

Fig. 1 Research methodology

Table 1 How to identify a victim of bullying

Victim parameter	Data source
Show deteriorating grades	Academic report
Regular absenteeism	Attendance records
Being picked on, pushed, punched, etc. (physically harassed)	CCTV images
Downfall of social skills	Registration for school events and extracurricular groups
Suffering from learning or mental disabilities	Counselor reports
Unwilling to go to school regularly	Attendance records
Random bruises, missing belongings or torn clothing	CCTV images
Prone to attacks of anxiety	School medical reports
Alone at lunch-breaks	CCTV images
Experiences regular nightmares	Medical room report
Starts bullying younger or weaker kids to vent out the frustration	CCTV images

are used to filter the data. In the proposed model, it is planned to integrate AI tools with school infrastructure and data like cameras with microphones, student portals containing community forums where students and teachers interact, attendance of students, their scorecards, etc. Data used for analysis and a complete infrastructural setup is discussed below in Tables 1 and 2.

Table 2 Bullying perpetrator parameters and data sources

Perpetrator parameters	Data source
Rude behavior with students as well as teachers	CCTV images, audio, school report
Low grades	School report
Lacks empathy or guilt	School report
Feeling of entitlement because of being good in school, sports or belonging to a prominent family	School report
Short-tempered and having emotional outbursts	CCTV images, audio, school report
Usually popular or among a big group	CCTV images, audio, school report
Regularly get into trouble with authority	School report

2.2 Integration with School Infrastructure

Recordings of playground, common-area (like corridor, locker rooms, etc.) and classes will be taken along with their audios via cameras that are installed. More detailed information associated with students will be extracted from student portals. This will further help in understanding and analyzing student behavior and personality. This raw information is then reworked into structured data, which will supplement the learning algorithm in predictions and analysis. Based on this, appropriate action can be taken by school authorities. This method can also be inverted and be used to discern the victims of harassment.

Data Analysis:

Photos uploaded by the students on community forums along with acquired video footage from CCTV are split into images (see Figs. 2 and 3) and ran through the algorithm to identify: drugs, number of faces, anxiety attacks, crying, isolation, fighting, torn clothes, bruises, sleeping, smoking, hard drinks, gore, explicit and adult content. The image classifier uses CNN and pre-trained network called Darknet-19 (trained

Fig. 2 Sample images (in case of bullying) from dataset

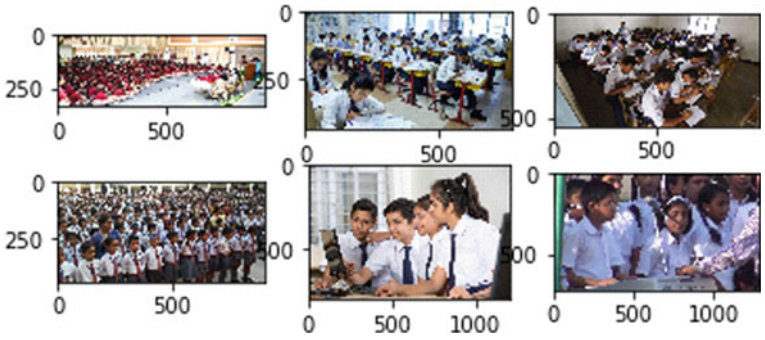

Fig. 3 Sample images (non-bullying) from dataset

on ImageNet dataset), along with LSTM which provides the capability to process sequence of image data with feedback connections. When a bullying scenario is detected by the CNN-LSTM architecture, faces of all those involved or present in the particular frame are detected using the popular object detection algorithm You Only Look Once (YOLO). These faces are input into another simple CNN, namely a Siamese network, which tries to identify the perpetrator by matching the input with the student database already present.

Audios which are mapped to text using Google Cloud Speech API alongside comments at student community are further used to determine the following features: tone, amplitude and pitch of voice, language used (explicit or not), uppercase text, text length and sentiments, threatening statements, trolling, unpleasant comments and distasteful words. Other attributes like low attendance, incompetent grades, enrolment in extracurricular activities, teacher–student interaction, frequency of councilor appointments and behavior report by staff will also be considered. Data for these inputs is converted from physical form into digital form first.

2.3 Techniques Involved

Convolution neural network is a type of neural network (NN) that provides the capability to convert pixels into well-structured data [5]. CNNs replicate the function of the frontal lobe of the human brain (cerebral cortex), which is responsible for processing audio visual stimulus in humans. To process images, CCTV footage is spliced into still images and then each frame is analyzed to extract the crucial and important features which can be further analyzed for more refined results.

Proposed network architecture for video classification is shown in Fig. 4. It has been already shown that adding LSTM (which extract global temporal features) after CNN, the local temporal features obtained from optical flow are also of great importance [10].

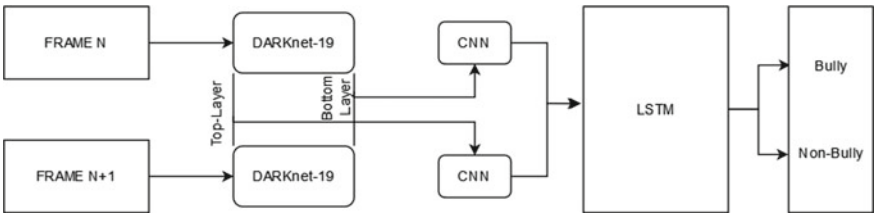

Fig. 4 Architecture of model

Optical flow is due to displacement of boundaries or movement of object across two consecutive frames. Optical flow is best used for action recognition, so its functionality is mimicked by taking two consecutive frames as input to training model. These consecutive frames are fetched to pre-trained CNN model (Darknet-19). Then, both of the frame values from the bottom layer of pre-trained model are fed as an input to additional CNN. Additional CNN network is now to supposed to learn from the local motion features including the invariant features by comparing the both frame. The top layer of the pre-trained network is also fetched to another additional CNN to learn from the comparison of high-level features of both the frames. Furthermore, the output of both the additional CNN is fully connected with LSTM cell, which further classifies the images as bully and non-bully.

When the image is classified as bully, the YOLO algorithm, which is an object detection algorithm, is used to detect all the faces present in the "bully" frame, using a vector of bounding boxes (see Fig. 5). It uses a convolutional neural network (CNN) to complete this task. The structure of the CNN used and a brief working is shown in Fig. 5. The input image is divided into grids or regions, and bounding boxes are predicted for each of these regions. The prediction vectors for each region contain six elements, namely [x, y, w, h, c, p], where x, y, w and h are the coordinates of the bounding boxes, c is the confidence and p is the probability of occurrence of faces, i.e., if the algorithm fails to detect any faces, p becomes equal to 0 and the remaining values are not defined.

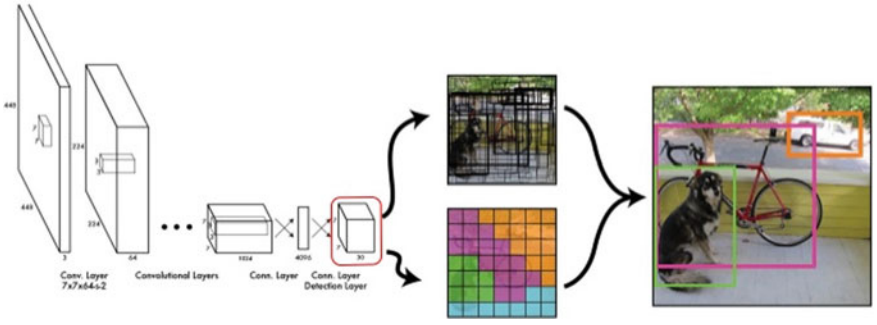

Fig. 5 YOLO algorithm

For unambiguous and noise-free detection, threshold values are set, in order to filter-out disturbances. Only regions that have their probability (p) value exceeding the threshold are considered. To further improve quality of predictions, Intersection over Union (IoU) and non-max suppression are performed. Non-max suppression helps in eliminating any bounding regions that might have detected an already detected feature or face. The final bounding boxes received after the complete procedure are sent as inputs into a Siamese network for facial recognition.

Since only one picture of each student will be present in the database, training a deep learning algorithm to map the received images to one stored in the dataset will not be feasible. Due to this, a Siamese network, another variation of the convolutional neural network that is a one-shot learning algorithm is used. It gives high performance in applications and scenarios where there is not a large amount of data belonging to each data class.

A Siamese network consists of two parallel neural networks, with the same weights and parameters. It consists of convolutional, pooling and dense layers just like a regular CNN, but what distinguishes it from it is that it is bereft of a softmax/sigmoid activation at the last layer. Thus, the encoding of an image is received as an output instead of a category. The contrastive loss or difference between encodings received from the two parallel networks is calculated to ascertain the similarity between the input images.

The faces inside the bounding boxes predicted by the YOLO algorithm are extracted and provided as input to one of the two parallel networks. The other network receives images from the database of students, and the difference of the received encodings in calculated. The image having the least difference is considered to be "identified" as one of those present in the bullying frame. To fasten the process and reduce computational needs, the encodings of all students in the database were generated in advance using the same Siamese network, and only difference calculation was done during the test phase. Immediate alerts, including the identity of those involved, are then sent to the authorities. Figure 6 displays the working of a Siamese network for facial recognition.

For audio analysis, we have mapped CCTV voice output with Google Cloud Speech API which uses CNN and provides real-time streaming of speech recognition and conversion from audio to text. This lies within our CCTV and Google Cloud Storage for sentiment analysis to be done on it.

For text analysis, mentioned words are mapped with sentiment analysis dictionary ("Liu and Hu opinion lexicon" containing 6800 positive and negative words [4]). To extract feature from the text, multinomial Naïve Bayes is used (refer Fig. 7). It helps in classification of bad words and rude comments from audio-to-text converted files as well as from student's community portal including explicit and vulgar remarks, text length as well as usage of upper-case letters in community forums, etc. All such attributes are then listed for feature extraction by the model.

Even data like medical records, attendance, grades and teachers remark from student portals is used and processed for feature extraction. Logistic regression modeling is used for this analysis.