INSTITUTE FOR HOMELAND SECURITY

REMOTE DETECTION OF ANGER: WEARABLES

Institute for Homeland Security

Sam Houston State University

Zeno Franco, PhD

Remote Detection of Anger – Wearables

Author: Zeno Franco, PhD
For: Sam Houston State University

Executive Summary

In light of recent and historical active shooter and other violent episodes in places of work, strategies that can rapidly identify high risk incidents using remote sensing systems are of increasing importance. Preliminary work using wristband sensors or smart watches has been successful in isolating 12 gesture patterns associated with rage responses in US military veterans. Generalizing these strategies to use machine learning based systems designed for real-time processing of security camera video may provide important, actionable information to employers, business campus security personnel, and law enforcement.

- Potential for violence exists in all of these sectors, as well as in private business associated with each. Current approaches are limited.
- Little is known about anger and how it is displayed in physical reactions (i.e. gestures).
- We use prior research findings to help businesses identify potentially angry workers and then apply an intervention such as the peer-support model.
- This approach can be used with commercially available wearables, smartphones, and other personal devices
- Intrusive, and best for individuals who have already recognized they have an issue and are willing to collaborate with therapists, EAP, or a court to work on addressing anger management.
- May be coupled with employee peer support in some organizations

Background

Intense expression of anger in many social situations can cause serious disruption. This is particularly the case in workplace environments where unresolved friction within teams or between individuals has led to increased workplace violence in recent years. For individuals with a history of anger management problems, there are countervailing considerations around safety and comfort of coworkers on the one hand, and the right to work on the other. Workers struggling with anger management problems are common in many fields from frontline workers in entry level jobs, to professionals working in emotionally intensive environments such as first responders and intelligence officers. Further, while there is increased national recognition of the importance of ensuring veterans have solid job opportunities after returning from service, a small percentage of this population suffers from anger management issues, often related to combat exposure and under-treated PTSD symptoms.

For individuals suffering from anger management difficulties, comparatively intrusive monitoring and early detection approaches may be welcomed as part of a recovery, work reintegration process, or as a way for the individual to better understand their own warning signs related to frustration build-up. Wearable activity detection systems have become more commonplace in the form of smartwatches and other sensor-based platforms. Recent research with US military veterans to use wearable sensors to detect angry gestures, as well as other research examining emotion detection using facial expressions and vocalization present important avenues toward balancing risk considerations with potentially violent employees.

Types of Anger

Several dimensions of anger have emerged that can create a personalized picture of the anger experience, such as 1) internalization, 2) desire to coerce others; psycho-physiological responses including 3) increased impulsive actions and 4) autonomic arousal; and directly observable activities such as 5) physical aggression, 6) verbal expressions of anger, and 7) relational or indirect aggression [9]. Specific behaviors associated with the emotion of anger include direct aggression such as aversive verbalizations (e.g., yelling, screaming, arguing noisily, criticizing, using sarcasm, insulting), physical aggression toward people (e.g. pushing, shoving, hitting, kicking, throwing objects), destruction of property, and provocative bodily expressions (e.g., negative gesticulation, menacing or threatening movements, physical obstruction of others); as well as less easily observed indirect expression of aggression through social relationships [1]. However, the internal phenomenological experience of anger (i.e., the nuances of the emotion itself), and the relationship between the emotion and its specific external expression remain largely uncharacterized in the social sciences [1, 2]. Moreover, while these general efforts to develop an understanding of the dimensions of anger experience are important, they have not yet addressed the use of individual patterns in early warning signs for aggression.

Emotion detection in sensor networks - beyond simple sentiment analysis

Physiological signals are a useful metric for providing general feedback about emotion states [3]. High systolic blood pressure, frequency of galvanic skin responses, heart rate and diastolic blood pressure are all potential indicators of anger [4]. Beside physiological cues, acoustic features such as pitch timing, voice quality, and articulation of speech highly correlate with human emotions [5]. Angry speech typically has a high median, wide range, wide mean inflection range, and a high rate of change. Some research discovered vowels of angry speech to have the highest pitch [5]. An early study [6] discovered the importance of specific whole body features of posture, such as leaning direction, and head position, (e.g., up, down, and tilted) for discriminating between affective states.

Collectively, prior studies [7, 8] suggest that anger is indicated by large, fairly fast, and jerky movements, while sadness is exhibited by fluid, slow movements. Since signals are treated as frame, statistic values of mentioned features (i.e. means and standard deviations) are also taken into account in this work. A user-dependent system uWave [9]was developed to recognize 8 simple gestures from Nokia vocabulary with 98.6% accuracy. In existing studies, abrupt changes in acceleration, which could represent valuable information to detect aggressive

gestures, are estimated by noise and minor hand shake/tilt, which are then discarded in data quantization process.

Sensor Detection Strategies for Angry Gestures

Our work has centered around early crisis detection in US military veterans using simpler strategies such as brief weekly self-report into a veteran peer mentor, but also more complex approaches that move beyond self-report to objective, sensor based behavioral data [10-14]. This interdisciplinary work takes advantage of ethnographic approaches to characterize angry gestures from the perspective of the veterans themselves, then working to create a data set of gestural information using accelerometer data from a smart wristband, and finally using machine learning to isolate patterns that can identify specific angry gestures.

The initial ethnographic work identified attenuated behaviors which may serve as early warning signs of aggression, low level aggressive behaviors, and examples of higher level aggressive behaviors (Table 1). The attenuated behaviors deserve significant attention because they may prove to be critical to heading of an aggressive crisis, however they are much more difficult to detect using wearable sensors at least with currently available technology.

Attenuated Behaviors - Angry Crisis Warning Signs	Low Level Aggressive Crisis Behaviors	High level Aggressive Crisis Behaviors
Involuntary • Shaking • Facial twitch • Stiffening body	***Throwing gestures*** · Money on bar · Keys on table · Phone across table	***Grand gestures*** · Sweep obj. off table · Flipping table over · Throwing lamp
Voluntary • Cocky stare • Posturing (widen stance) • Stillness	***Hand Gesture*** · Knife hand · Pointing · Middle finger · Making a fist/fist in air	***Melee*** · Throwing bottle · Throwing bar stool · Throwing people · Chasing people
Vocalization changes • Talking louder • Talking over someone • Muttering under breath	***Foot gestures*** · Tapping · Shaking leg · Kicking object	
Social Withdrawal • # of phone calls • # of texts • TCP/IP meta data	***Physical contact*** · Poke · Push · Enter other's personal space	

Table 1. Early warning signs leading up to angry outburst

We used this initial ethnographic work to create a set of 12 clearly aggressive gestures to try to isolate using accelerometer data from the E4 Empatica wristband (Table 2). Full paper available from: https://idl.iscram.org/files/zenofranco/2018/2159_ZenoFranco_etal2018.pdf

Figure 1. 12 Angry Gestures. Full paper available from: https://ieeexplore.ieee.org/abstract/document/8754451

Problems

Numerous practical and research problems exist with implementing this type of activity detection approach. For example, discriminating between high emotion/intensity gestures that are and are not driven from anger is a key issue. False positives have implications for over-alerting, alert fatigue, and resource management. Conversely, false negatives have ethical and legal risk as systems that do not accurately detect true positives may fail to alert when an individual is in a critical state, and presents a risk to themselves or others.

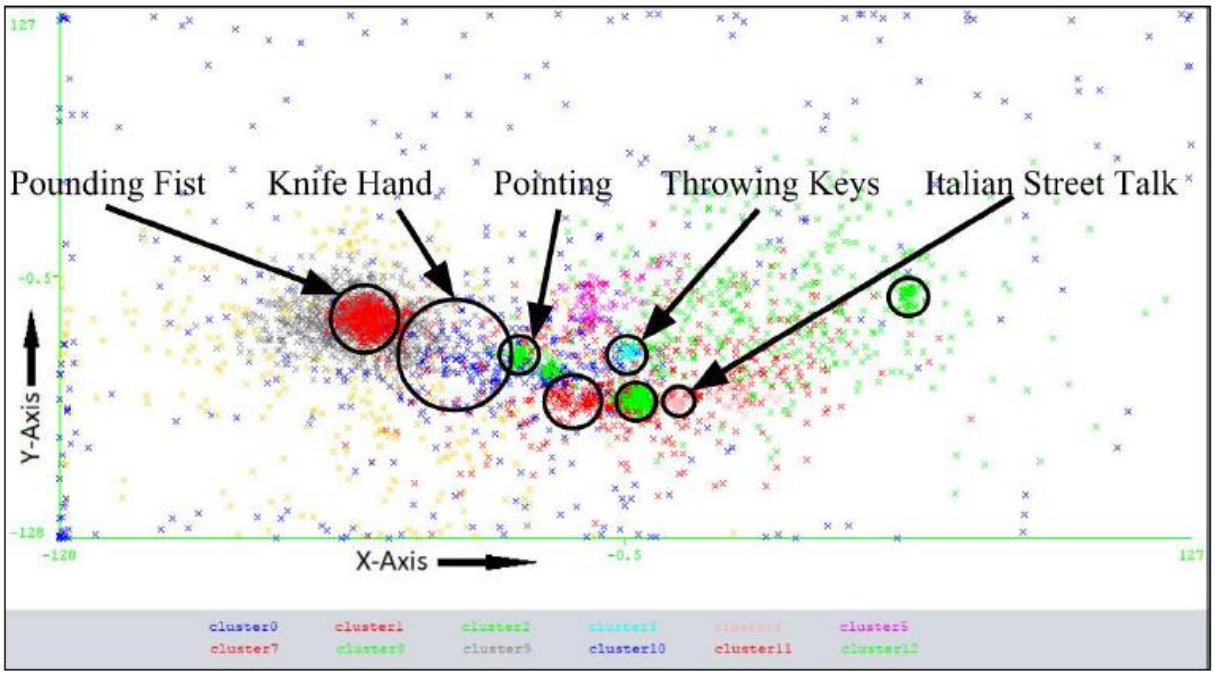
From our own research, precursors to anger may be particularly difficult to detect where using this approach when the information channel for precursor data differs from the acute event data channel. For example, veterans in our focus groups identified bodily shaking, facial twitches, body stiffening, stillness (the absence of gestural data), postural changes, and subvocalizations as key precursors or early warning signs that simple wearables focused on accelerometer based gestural signatures may miss.

Individual differences, including handedness, preferences for where or how wearables are worn, and gender may also require different machine learning driven models for prodromal and acute anger episodes. For example, women likely express anger in somewhat different ways than men in terms of gestural patterns, especially in the prodromal phase before acute confrontation. Women also may have different preferences for where and how wearables are worn which may result in different signals from a wearable sensor set.

Wearables for anger detection is also an inherently intrusive approach, likely to work best with full disclosure and consent with individuals who are aware they have a serious problem with anger and are willing to sacrifice privacy and control in order to help themselves minimize the consequences of their anger. For the research that we have done on veteran anger, for example, we have screened for individuals suffering from serious problems related to anger who understand that the benefits to other veterans experiencing similar disruptions in their lives may be significant. These individuals directly note that the trade-off between privacy and personal and/or societal benefit is worth the risks.

Future

Ultimately, the goal of any such system must be to integrate early warning alerting into another system capable of fielding social support to the individual. We have conceptualized tying in object oriented or API based systems that can real-time alerts to smartphones used by trained mental health peer mentors or to electronic health record (EHR) systems used by clinicians. For example, in a recent commercialization grant around these strategies, we integrated an API for Consolidated Clinical Document Architecture (CCDA) compliant alerting to multiple EHR systems.


Pounding Fist
Knife Hand
Pointing
Throwing Keys
Italian Street Talk
Y-Axis
X-Axis
127
-0.5
-128
-128
-0.5
127
cluster0
cluster1
cluster2
cluster3
cluster4
cluster5
cluster7
cluster8
cluster9
cluster10
cluster11
cluster12


Classes
FistInAir
HandsOnHead
ItalianStreetTalk
KnifeHand
MiddleFinger
Pointing
PokingChest
PoundingFist
Shove
SweepOffTable
ThrowKeys
ThrowMoney
ThrowThings

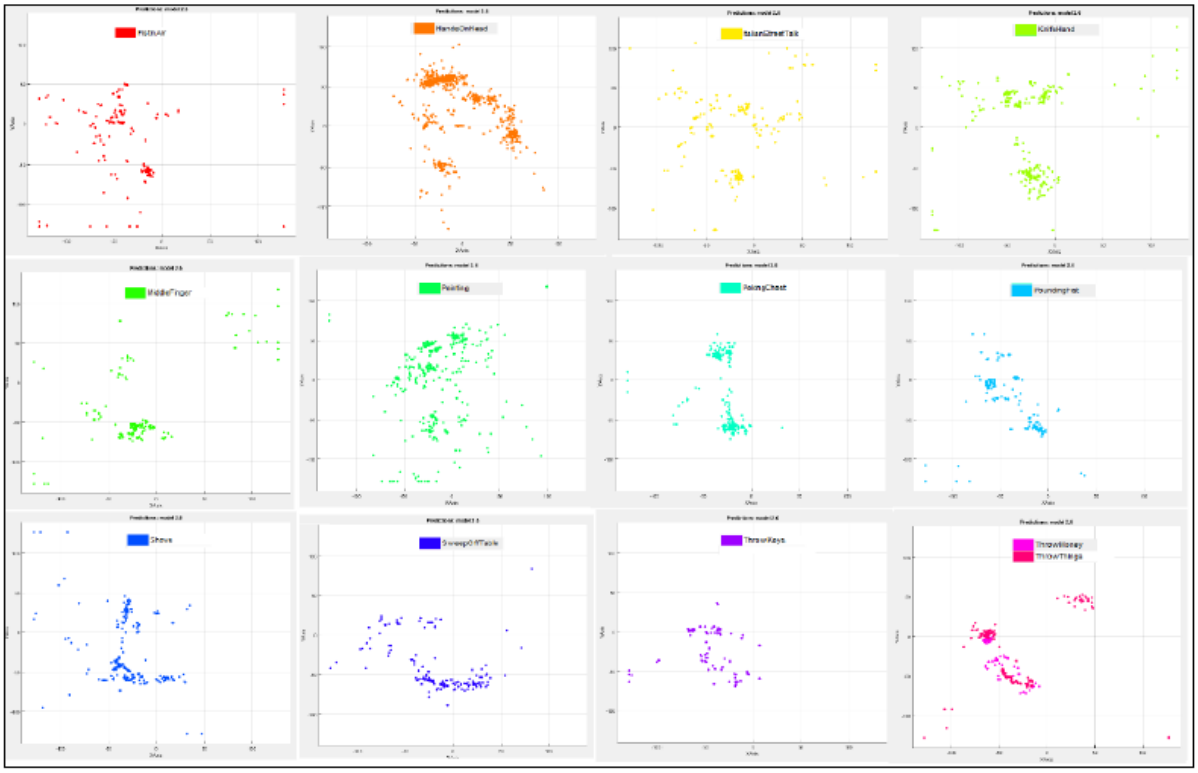


Figure 2: Detailed accelerometer pattern recognition with 12 angry gestures. Full details available: https://epublications.marquette.edu/cgi/viewcontent.cgi?article=1477&context=theses_open

Advanced Considerations

Next steps for wearable based detection of anger include data fusion from multiple data streams. This might include other sensor platforms, including voice, but also social context, GPS, and other relevant data that can help real time artificial intelligence systems estimate the probability that an event is an acute expression of anger or early warning sign, versus a high intensity expression of emotion that is not anger. Further, while machine learning approaches show promise for anger detection, a sociotechnical systems approach is key, and technological alerting systems must be coupled with increased and continual training of human crisis responders. Key decision support systems for human responders area also an important area for further exploration.

References

[1] R. DiGiuseppe, R.C. Tafrate, Understanding anger disorders, Oxford University Press2007.
[2] C. Boettiger, A. Hastings, Quantifying limits to detection of early warning for critical transitions, Journal of the Royal Society Interface 9(75) (2012) 2527-2539.
[3] R. DiGiuseppe, R.C. Tafrate, Anger treatment for adults: A meta-analytic review, Clinical Psychology: Science and Practice 10(1) (2003) 70.

[4] D.E. Hinton, A. Rasmussen, L. Nou, M.H. Pollack, M.-J. Good, Anger, PTSD, and the nuclear family: A study of Cambodian refugees, Social science & medicine 69(9) (2009) 1387-1394.
[5] F. Nasoz, C.L. Lisetti, K. Alvarez, N. Finkelstein, Emotion recognition from physiological signals for user modeling of affect, Proceedings of the 3rd Workshop on Affective and Attitude User Modelling (Pittsburgh, PA, USA, 2003.
[6] R.W. Picard, E. Vyzas, J. Healey, Toward machine emotional intelligence: Analysis of affective physiological state, IEEE transactions on pattern analysis and machine intelligence 23(10) (2001) 1175-1191.
[7] M. El Ayadi, M.S. Kamel, F. Karray, Survey on speech emotion recognition: Features, classification schemes, and databases, Pattern recognition 44(3) (2011) 572-587.
[8] C. Shan, S. Gong, P.W. McOwan, Beyond Facial Expressions: Learning Human Emotion from Body Gestures, BMVC, Citeseer, 2007, pp. 1-10.
[9] J. Liu, L. Zhong, J. Wickramasuriya, V. Vasudevan, uWave: Accelerometer-based personalized gesture recognition and its applications, Pervasive and Mobile Computing 5(6) (2009) 657-675.
[10] Z. Franco, K. Hooyer, R. Rizia, A.K. Patwary, M. Armstrong, B. Semaan, C. Kuziemsky, B. Curry, S.I. Ahamed, Crisis warning signs in mhealth for military veterans: A collaborative design approach, Proceedings of ISCRAM2016 Conference, Rio de Janiero, Brazil, 2016.
[11] Z. Franco, K. Hooyer, T. Roushan, C. O'Brien, N. Johnson, B. Watson, N. Smith-Watson, B.C. Semaan, M. Flower, J. Tasse, Detecting & Visualizing Crisis Events in Human Systems: an mHealth Approach with High Risk Veterans, ISCRAM, 2018.
[12] R. Rizia, Z. Franco, K. Hooyer, N. Johnson, A.K. Patwary, G.M.T. Ahsan, B. Curry, M. Flower, S.I. Ahamed, ipeer: A sociotechnical systems approach for helping veterans with civilian reintegration, Proceedings of the 2015 Annual Symposium on Computing for Development, 2015, pp. 85-93.
[13] R. Rizia, Z. Franco, N. Johnson, K. Hooyer, A.K. Patwary, G.T. Ahsan, M. Flower, B. Curry, S.I. Ahamed, Collaborative Design with Veterans: Identifying challenges of designing mhealth solution for veterans, 2015 17th International Conference on E-health Networking, Application & Services (HealthCom), IEEE, 2015, pp. 358-362.
[14] N. Johnson, J. Coelho, M.F. Hossain, T. Kissane, W. Frydrychowi, M. Praveen, Z. Franco, K. Hooyer, P. Annapureddy, S.I. Ahamed, Understanding Veterans Expression of Anger Using Social Media Analysis, 2020 IEEE 44th Annual Computers, Software, and Applications Conference (COMPSAC), IEEE, 2020, pp. 1689-1694.

INSTITUTE FOR HOMELAND SECURITY

Sam Houston State University

The Institute for Homeland Security at Sam Houston State University is focused on building strategic partnerships between public and private organizations through education and applied research ventures in the critical infrastructure sectors of Transportation, Energy, Chemical, Healthcare, and Public Health.

The Institute is a center for strategic thought with the goal of contributing to the security, resilience, and business continuity of these sectors from a Texas Homeland Security perspective. This is accomplished by facilitating collaboration activities, offering education programs, and conducting research to enhance the skills of practitioners specific to natural and human caused Homeland Security events.

Institute for Homeland Security
Sam Houston State University

Franco, Z. (2022). **Remote Detection of Anger: Wearables**. (Report No. IHS/CR-2022-2046). The Sam Houston State University Institute for Homeland Security.
https://ihsonline.org/Research/Technical-Papers/Wearables-Remote-Detection-of-Anger