MAY 2013

Special points of interest:

- **Novel approaches for Detection of Post-Traumatic Stress Disorder (PTSD)**
- **"Honest Signals"**
- **Privacy and Security are of Paramount Concern**
- **Mobile apps**
- **IRBs—Institutional Review Boards**
- **DSM-IV APA's Diagnostic & Statistical manual of Mental Disorders Ver. IV, Ver. V, due out May 2013**

Inside:

Detection & Computational Analysis of Psychological Signals (DCAPS) Information

DCAPS Program Introduction

By CAPT Russell Shilling, Ph.D., MSC, USN
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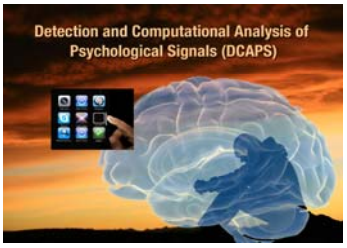
As a result of combat exposure, servicemembers may return home from deployments with psychological health challenges and find it difficult to reconnect with



family and society at large. According to the Department of Veteran Affairs' National Center for Post-Traumatic Stress Disorder (PTSD)[15], studies show that between 12 and 25 percent of military personnel who had returned from Afghanistan and Iraq as of 2008 may suffer from PTSD. Despite best efforts to improve awareness and care, additional studies reveal that only a small fraction of servicemembers seek help dealing with psychological health issues.

The Detection and Computational Analysis of Psychological Signals (DCAPS) program aims to develop novel analytical tools to assess psychological status of servicemembers with the goal of improving psychological health awareness and enabling them to seek timely help.

DCAPS tools are being developed to analyze patterns in everyday behaviors to detect subtle changes associated with post-traumatic stress disorder, depression and suicidal ideation. In particular, DCAPS strives to advance the state-of-the-art in extraction and analysis of "honest signals" from a wide variety of sensory data inherent in daily social interactions. DCAPS is not aimed at providing an exact diagnosis, but at providing a general metric of psychological health.

DCAPS is also developing and validating novel algorithms for detecting distress cues from data such as text and voice communications, daily patterns of sleeping, eating, social interactions and online behaviors, and nonverbal cues such as facial expression, posture and body movement. The outcomes of these analytical algorithms would be correlated with distress markers from neurological sensors for

improved understanding of distress cues.

The DCAPS program is also exploring the practical and ethical implications of using these new approaches. Privacy and security are of paramount concern. Program data will be collected with the informed consent of individuals involved and stored in a secure, private data-sharing framework. DCAPS is developing a novel trust/privacy framework. Researchers on the DCAPS program have been intimately involved in the development of international privacy standards, which are being incorporated directly into the program.

Privacy/Trust Framework

By Sandy Pentland/ID³/MIT Media Lab

Summary

Data sharing is key for getting timely help for distressed users, but data sharing must be secure and should maintain user privacy and control. Psychological health tools will only be effective if the users trust that their data remains private.

To ensure privacy and user control, DCAPS is developing a Trust Network that implements legal agreements for data sharing. The openPDS (open Personal Date Store) Trust Network[14] being developed under DCAPS is built on frameworks used in banks and hospitals and follows the recommendations for individual data made by the U.S. National Strategy for Trusted Identities in Cyberspace (NSTIC).

Under the openPDS Trust Network, the user controls the amount of data sharing through multi-tiered sharing levels and binding legal agreements. In addition, it protects the user privacy through data aggregation using anonymizing privacy mechanisms and encrypted storage of sensitive data.

Goal

Develop tools to assess psychological status by analyzing everyday behaviors while maintaining privacy and control by the individual user.

Examples of user behaviors that can contribute to assessment of psychological state include content of verbal behaviors in speech and text, patterns of sleeping, eating, social interactions, online behaviors and nonverbal cues such as tone of voice, expression, posture and movement patterns.

Capabilities

It is important for the DCAPS solution to be not only compatible but also aligned with policy and legal standards. The openPDS Trust Network is compatible with and incorporates best practice suggestions of the U.S. Consumer Privacy Bill of Rights, the U.S. National Strategy for Trust Identities in Cyberspace, the Department of Commerce Green Paper, and the Executive Office of the President's International Strategy for Cyberspace.

In addition, it follows Fair Information Practices (FIPs), which have mandated that personal data be made available to individuals upon request. The individual user owns his or her data.

Status

The dominant industry position seems to be that regulators should focus more on data use than collection, with the idea that all personal data be required to include metadata about provenance and use permissions. Such metadata would allow automatic auditing, and would allow applications to go back to users for additional permissions when required.

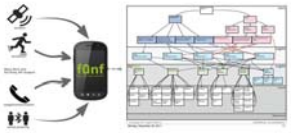


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Figure 1: Measuring DSM IV Behavior Criteria Using Cell Phone Signals

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Figure 2: Report from Davos 2013; the New Deal on Data

Text and Voice Analytics for Psychological Distress Detection

By Rohit Prasad, Raytheon/BBN Technologies

Figure 1: Distress detection from modern day communications.

Summary

State-of-the-art mental health evaluation and diagnosis rely on self-reports from individuals and/or their family members. These reports tend to be inaccurate, leading to severe under-diagnosis. In contrast to self-reporting, electronic text and voice interactions in modern day communications on the Internet and smartphones provide a unique opportunity for continually extracting "honest" signals, for a more accurate assessment of psychological status.

Goal

Our goal is to develop a Medical Informatics and Analytics Toolkit (MINAT) that automatically detects indicators of Post-Traumatic Stress Disorder (PTSD), depression and suicidality from informal text and voice interactions. This toolkit leverages a combination of verbal and non-verbal cues and social and non-social online activities for an accurate assessment of psychological status. In its ultimate realization, MINAT will greatly improve the quality, richness (e.g., relevant contextual evidence) and timeliness of information available to medical professionsals in clinical settings in the form of decision support tools, and non-clinical settings such as screening for redeployment.

Capabilities

MINAT is a novel combination of natural language processing, voice stress analysis and data-driven machine learning for extracting DSM-IV (Diagnostic and Statistical Manual of Mental Disorders, Fourth Edition) constructs for PTSD, depression and suicidality from informal text and voice data. The system analyzes incoming data in real time and provides an assessment of the person's psychological state across DSM-IV axes of *affect*, *behavior*, *trauma exposure*, *cognition* and *domains of impairment*. MINAT also triages individuals based on their risk to harm themselves or others.

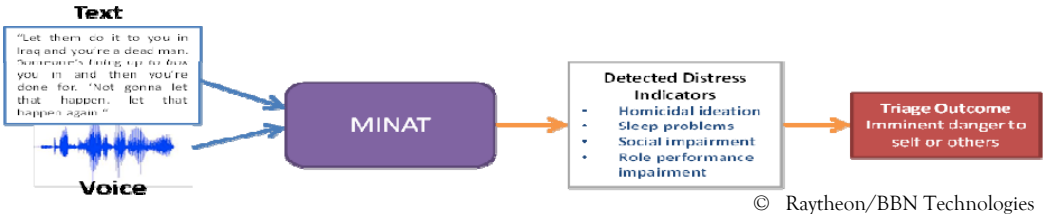

Figure 2: MINAT Capabilities

Status

The BBN-led industry and academia team has developed a first-of-its-kind system for extracting DSM-IV constructs from informal text such as posts on forums. This system employs BBN's state-of-the-art natural language processing and statistical classifiers trained on forum messages labeled by psychologists. Another innovation has been the use of probabilistic reasoning for triaging individuals based on the automatically detected DSM-IV constructs. For voice analytics, BBN has developed techniques that combine "*what is the person saying*" (lexical features), "*how is the person saying it*" (voice-acoustic features), and "*how is the person interacting in dyadic settings*" (interaction cues). The combination of lexical and voice-acoustic features (e.g. vocal jitter, pitch variation, energy) has resulted in best-reported accuracy of emotion recognition on publicly available datasets.

Neurological Analysis for Psychological Distress Detection

By Rohit Prasad, Raytheon/BBN Technologies

Summary

Authentic screening of psychological status is dependent on the ability of eliciting "honest" responses to targeted stimuli. Analyzing data from multiple sources such as human language (text and voice), body posture/movement and eye gaze, is likely to result in more reliable outcomes than any single sensory data. Neurophysiological sensors such as electroencephalography (EEG) sensors have also been proven to be effective for detecting distress, but their cost and form factor has been prohibitive for use in non-clinical settings. However, recent advances in EEG technology have resulted in affordable, ergonomic sensors that are commercially available, enabling fusion with other sensory data for distress detection.

Goal

The team's goal is to develop a novel elicitation tool and a multi-sensor data fusion and analysis platform that will enable more accurate detection of indicators of mental health disorders. The experimental findings from this research would result in: (a) novel screening and clinician support tools that fuse multiple sources of sensor information, and (b) identification of more honest response-to-stimuli criteria that can help refine the definition of PTSD.

Capabilities

The team's work brings together Advanced Brain Monitoring's (ABM) advanced wireless EEG sensing capabilities, Intific's sandbox Neuro Bridge technology for rapid development and exploration of complex immersive experiences, and BBN's expertise in development and application of audio, text, video and multi-modal processing and machine learning techniques.

The team seeks to develop: (1) new approaches in creating effective, multimodal response elicitation scenarios, i.e. stimuli sequences, for eliciting honest responses for assessing psychological status including interactions with virtual humans, images/videos, audio, (2) comparison of effectiveness of individual sensors in detecting PTSD indicators; and, (3) improved detection of PTSD related distress by fusing information from multiple sensors.

Status

Intific has developed a preliminary version of the elicitation tool that logs, timestamps and correlates the data streams of multiple sensors during the subject's experiences with immersive simulation stimuli. The tool supports all planned types of stimuli and collects audio, text, HD video, EEG and heart rate synchronized with the scenario events.

ABM, BBN and Intific have together created a comprehensive set of response elicitation scenarios. The IRB for the ABM facility to run a protocol for the healthy and stressed groups has been approved.

BBN has conducted preliminary experiments on the publicly available DEAP corpus (Database for Emotion Analysis using Physiological Signals). The machine learning approach has resulted in state-of-the-art performance on recognition of affective dimensions from EEG signals in the DEAP corpus.

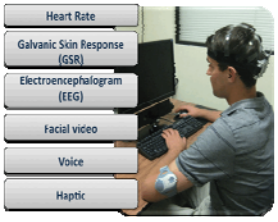

Figure 1: Sensors for distress detection.

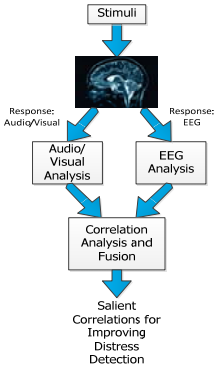

Figure 2: Multi-sensor data analysis and fusion.

Multisense and SimSensei - A Multimodal Research Platform for Realtime Assessment of Distress Indicators

By Louis-Philippe Morency, Albert (Skip) Rizzo, et al., USC/ICT

Figure 1: Multisense — Real-Time Multimodal Computational Analysis

Note: Image is of the USC/ICT Project Director, Alesia Egan demonstrating Multisense in action

Figure 2: SimSensei — Real-Time Virtual Human Platform

Summary

The Institute for Creative Technologies (ICT), University of Southern California's pioneering efforts within DARPA's Detection and Computational Analysis of Psychological Signals (DCAPS) project encompass advances in the artificial intelligence fields of machine learning, natural language processing and computer vision. These technologies identify indicators of psychological distress such as depression, anxiety and PTSD, and are being integrated into ICT's virtual human application to provide healthcare support.

Goals

This effort seeks to enables a new generation of clinical decision support tools and interactive virtual agent-based healthcare dissemination/ delivery systems that are able to recognize and identify psychological distress from multimodal signals. These tools would provide military personnel and their families' better awareness and access to care while reducing the stigma of seeking help.

For example, the system's early identification of a patient's high or low distress state would generate the appropriate information that could help a clinician diagnose a potential stress disorder. User-state sensing can also be used to create long-term patient profiles that would be used to assess change over time.

Capabilities

ICT is expanding its expertise in automatic human behavior analysis to identify indicators of psychological distress in people. Two technological systems are central to the effort.

Multisense automatically tracks and analyzes in real-time facial expressions, body posture, acoustic features, linguistic patterns and higher-level behavior descriptors (e.g. attention and fidgeting). Multisense infers from these signals and behaviors, indicators of psychological distress that directly inform SimSensei, the virtual human.

SimSensei is a virtual human platform able to sense real-time audio-visual signals captured by Multisense. It is specifically designed for healthcare support and is based on the 10+ years of expertise at ICT with virtual human research and development. The platform enables an engaging face-to-face interaction where the virtual human automatically reacts to the perceived user state and intent, through its own speech and gestures.

DCAPS is not aimed at providing an exact diagnosis, but at providing a general metric of psychological health.

Status

Data collection, analysis and development of the Multisense and SimSensei systems continue to move at a robust pace. Last year saw the completion of the face-to-face study, entailing over 150 interactions between human interviewer and subjects from control and veteran populations. From this study, indicators and behaviors associated with psychological distress were empirically defined and are now being observed in several rounds of "wizard of oz" studies. Here human subjects are interacting with a semi-automated SimSensei virtual human "Ellie," whose verbal and nonverbal behaviors are enhanced by two human "wizards" sitting in a proximate room. Results from this study are informing the development of Multisense and the fully-automated SimSensei platform.

Development of Multisense continues as analyses from the above studies suggest that patterns in smiles, gaze, head position and voice quality correlate with psychological distress. The system is being trained to sense these behavioral patterns and will continue to be trained on new indicators as they are defined.

Development of the SimSensei application remains focused. The system was updated with new speech lines, improved interface and new verbal and nonverbal behaviors.

Mobile Reality Analysis for Distress Detection

By Rohit Prasad, Raytheon/BBN Technologies

Summary

State-of-the-art mental health evaluation and diagnosis frequently rely on self-report by individuals and/or their family members. This reporting can be inaccurate and lacking in follow-up, leading to under-diagnosis and late treatment of disorders such as Post Traumatic Stress Disorder (PTSD), depression, and suicidal tendencies in both military and civilian populations.

Modern-day communication devices such as smartphones provide a pervasive platform that enables continuous sensing and unobtrusive monitoring of everyday behavior, while minimizing any self-report burden placed on service members. These devices can record frequency of interactions with other people, general levels of movement and activity, users' tone of voice, as well as other subtle and honest social signals. In fact, a sizeable proportion of the current DSM-IV symptoms that are used to diagnose various psychological health conditions focus on changes in behavior that can be effectively measured by smartphones.

Goal

The overarching goal for this effort is to develop an application that integrates passive sensing of honest social signals from sensors available on smartphones, detects distress from speech behavior and text analytics, and incorporates a novel trust framework to address data privacy and ownership issues.

The mobile application would enable service members to obtain continuous feedback on their mental health status and share that feedback with their social support group and care team. The use of this application would result in greater service member engagement in mental health services and treatment, provide care providers with reliable behavioral information to support interventions, and reduce cost and burden to the health care system.

Capabilities

DCAPS is intended to provide a privacy-assured, secure and scalable mobile sensing platform that gathers honest data from mobile phones, analyzes that data for patterns of psychological distress, stores the data securely and allows each individual to see and share feedback on their overall mental health status.

Status

The industry-academia team of Raytheon BBN Technologies (BBN), Cogito Corporation (Cogito), and Massachusetts Institute of Technology (MIT) has developed a prototype system for self-monitoring of psychological health. This prototype includes a data-gathering platform and is currently going through a significant initial clinical trial that looks at behavior from individuals experiencing symptoms of PTSD and depression. This behavioral data is being used to tune and evaluate the automatic symptom assessment engine. Additionally, the secure sharing and data storage infrastructure is going through a rigorous legal and technological audit and review.

Figure 1: The VetGuard mobile application allows veterans to self-monitor behavior components linked to mental health symptoms

Independent Evaluation and Assessment of Developer DCAPS Tools

By Roy Stripling, Et. al., UCLA/CRESST

Figure 1: Testing all of the DCAPS tools with a common veteran population allows CRESST to take their collective data – the assessments that each tool produces – and combine the individual assessments into an integrated assessment that may be more reliable and valid than the assessments that any individual tool can produce.

Summary

The National Center for Research on Evaluation, Standards and Student Testing (CRESST) at the University of California at Los Angeles (UCLA) has successfully executed evaluations on several distinct DCAPS technologies. Because DCAPS tools must serve common groups and purposes, CRESST can focus their evaluation on the developers' claims against this purpose using volunteers from this group in CRESST's tests.

Goals

Besides the tool-by-tool evaluation against developer claims, CRESST's effort seeks to develop a "behavioral calculus" capable of identifying relationships among sources of evidence and psychological constructs. It also seeks to develop an evaluation testbed implementing the behavioral calculus with interfaces to DCAPS tool outputs.

Through independent testing, CRESST determines the validity of the developers' claims for their tools and push beyond to test the collective potential of these tools to exceed their individual utility when used in combination.

Capabilities

CRESST has long contributed to the development of scientifically based evaluation and testing techniques, vigorously encouraged the development, validation and use of sound data for improved accountability and decision making, and aggressively explored technological applications to improve assessment and evaluation practice.

For DCAPS, CRESST serves as the developer-independent evaluator. To carry out these tests, CRESST seeks to recruit veteran volunteers from the greater Los Angeles area, which is home to an estimated 328,000 veterans. CRESST relies on professional clinicians trained to conduct diagnostic psychological evaluations to provide ground truth on the psychological condition of each volunteer. These ground truth assessments will be compared at the symptom level with the assessments produced by the DCAPS tools. Symptom-level data from these tools will be used to generate collective symptom- and condition-level assessments that are compared to the clinicians' assessments, using a method known as latent variable analysis. CRESST rounds out the evaluation by assessing each tool for usability, cost-effectiveness and user acceptability.

Status

CRESST is currently testing and refining the methods needed to recruit and clinically assess a representative population of veteran volunteers. In addition, CRESST is in constant communication with the tool developers to ensure that CRESST uses sensitive and fair methods when testing their tools. This summer, CRESST intends conducting additional pilot tests using beta versions of the developers' tools to ensure that CRESST, and their veteran volunteers, can use these tools as intended.

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