Optimizing targeted vaccination across cyber-physical networks: an empirically based mathematical simulation study

Targeted vaccination, whether to minimize the forward transmission of infectious diseases or their clinical impact, is one of the 'holy grails' of modern infectious disease outbreak response, yet it is difficult to achieve in practice due to the challenge of identifying optimal targets in real time. If interruption of disease transmission is the goal, targeting requires knowledge of underlying person-to-person contact networks. Digital communication networks may reflect not only virtual but also physical interactions that could result in disease transmission, but the precise overlap between these cyber and physical networks has never been empirically explored in real-life settings. Here, we study the digital communication activity of more than 500 individuals along with their person-to-person contacts at a 5-min temporal resolution. We then simulate different disease transmission scenarios on the person-to-person physical contact network to determine whether cyber communication networks can be harnessed to advance the goal of targeted vaccination for a disease spreading on the network of physical proximity. We show that individuals selected on the basis of their closeness centrality within cyber networks (what we call 'cyber-directed vaccination') can enhance vaccination campaigns against diseases with short-range (but not full-range) modes of transmission.
Inferring Person-to-person Proximity Using WiFi Signals

Today’s societies are enveloped in an ever-growing telecommunication infrastructure. This infrastructure offers important opportunities for sensing and recording a multitude of human behaviors. Human mobility patterns are a prominent example of such a behavior which has been studied based on cell phone towers, Bluetooth beacons, and WiFi networks as proxies for location. However, while mobility is an important aspect of human behavior, understanding complex social systems requires studying not only the movement of individuals, but also their interactions. Sensing social interactions on a large scale is a technical challenge and many commonly used approaches—including RFID badges or Bluetooth scanning—offer only limited scalability. Here we show that it is possible, in a scalable and robust way, to accurately infer person-to-person physical proximity from the lists of WiFi access points measured by smartphones carried by the two individuals. Based on a longitudinal dataset of approximately 800 participants with ground-truth interactions collected over a year, we show that our model performs better than the current state-of-the-art. Our results demonstrate the value of WiFi signals in social sensing as well as potential threats to privacy that they imply.

General information
State: Published
Organisations: Department of Applied Mathematics and Computer Science , Cognitive Systems, Stanford University
Authors: Sapiezynski, P. (Intern), Stopczynski, A. (Intern), Wind, D. K. (Intern), Leskovec, J. (Ekstern), Jørgensen, S. L. (Intern)
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Volume: 1
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Publisher: Association for Computing Machinery
Validation of a smartphone-based EEG among people with epilepsy: A prospective study

Our objective was to assess the ability of a smartphone-based electroencephalography (EEG) application, the Smartphone Brain Scanner-2 (SBS2), to detect epileptiform abnormalities compared to standard clinical EEG. The SBS2 system consists of an Android tablet wirelessly connected to a 14-electrode EasyCap headset (cost $300 USD). SBS2 and standard EEG were performed in people with suspected epilepsy in Bhutan (2014-2015), and recordings were interpreted by neurologists. Among 205 participants (54% female, median age 24 years), epileptiform discharges were detected on 14% of SBS2 and 25% of standard EEGs. The SBS2 had 39.2% sensitivity (95% confidence interval (CI) 25.8%, 53.9%) and 94.8% specificity (95% CI 90.0%, 97.7%) for epileptiform discharges with positive and negative predictive values of 0.71 (95% CI 0.51, 0.87) and 0.82 (95% CI 0.76, 0.89) respectively. 31% of focal and 82% of generalized abnormalities were identified on SBS2 recordings. Cohen's kappa ($\kappa$) for the SBS2 EEG and standard EEG for the epileptiform versus non-epileptiform outcome was $\kappa = 0.40$ (95% CI 0.25, 0.55). No safety or tolerability concerns were reported. Despite limitations in sensitivity, the SBS2 may become a viable supportive test for the capture of epileptiform abnormalities, and extend EEG access to new, especially resource-limited, populations at a reduced cost.

General information

State: Published
Organisations: Department of Applied Mathematics and Computer Science, Massachusetts General Hospital, University of Toronto, University of Manitoba, Brown University, Jigme Dorji Wangchuck National Referral Hospital, University of Washington
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Scopus rating (2014): SJR 2.163 SNIP 1.554 CiteScore 4.75
Fundamental structures of dynamic social networks

Social systems are in a constant state of flux, with dynamics spanning from minute-by-minute changes to patterns present on the timescale of years. Accurate models of social dynamics are important for understanding the spreading of influence or diseases, formation of friendships, and the productivity of teams. Although there has been much progress on understanding complex networks over the past decade, little is known about the regularities governing the microdynamics of social networks. Here, we explore the dynamic social network of a densely-connected population of ~1,000 individuals and their interactions in the network of real-world person-to-person proximity measured via Bluetooth, as well as their telecommunication networks, online social media contacts, geolocation, and demographic data. These high-resolution data allow us to observe social groups directly, rendering community detection unnecessary. Starting from 5-min time slices, we uncover dynamic social structures expressed on multiple timescales. On the hourly timescale, we find that gatherings are fluid, with members coming and going, but organized via a stable core of individuals. Each core represents a social context. Cores exhibit a pattern of recurring meetings across weeks and months, each with varying degrees of regularity. Taken together, these findings provide a powerful simplification of the social network, where cores represent fundamental structures expressed with strong temporal and spatial regularity. Using this framework, we explore the complex interplay between social and geospatial behavior, documenting how the formation of cores is preceded by coordination behavior in the communication networks and demonstrating that social behavior can be predicted with high precision.
Validation of the Smartphone Brain Scanner for the Detection of Epileptiform Discharges among Epilepsy Outpatients in Bhutan

Objective: To assess the Smartphone Brain Scanner-2 (SBS2)'s ability to detect abnormal and epileptiform cortical discharges compared to standard electroencephalogram (EEG) among people with epilepsy (PWE) in Bhutan.

Background: The SBS2 is a software application, utilizing a 14-lead headset connected wirelessly to an Android device. Portable, easily operated, and low-cost (<500USD per device), the SBS2 may aid in the diagnosis of epilepsy in resource-limited settings. Methods: PWE or suspected seizures in Bhutan underwent a SBS2 and a standard EEG (each ≥20 minutes duration). The SBS2 used circumference-matched EasyCaps with ring electrodes positioned at F3, C3, P3, O1, F4, C4, P4, O2, Fz, Cz, Pz, Fpz, A1, A2. The standard EEG (Xltek, Natus) used 10-20 system electrode placement and peripheral leads. Neurologists, blinded to clinical data, categorized recordings as normal or abnormal, and abnormalities as epileptiform or background. Each SBS2 recording was read once. Each standard EEG was independently assessed by ≥2 neurologists. A third neurologist or a group of neurologists resolved discrepancies. Results: 215 participants (53% female, mean age 25 years) completed both SBS2 and standard EEG with no safety or tolerability concerns. Epileptiform discharges were present on 25% and 15% of standard and SBS2 EEGs. For the detection of all abnormalities, the SBS2 had a sensitivity of 0.51, specificity of 0.84, and positive and negative predictive values of 0.65 and 0.74 versus standard EEG. For the detection of epileptiform discharges, the SBS2 had a sensitivity of 0.36, specificity of 0.94, and positive and negative predictive values of 0.68 and 0.84 versus standard EEG. Conclusions: The SBS2 EEG is specific but not sensitive for the detection of epileptiform discharges, and may have clinical relevance to help confirm a suspected epilepsy diagnosis in resource-limited settings. Sensitivity may be improved with hardware modifications including the addition of electrodes along the temporal chain.

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Web of Science (2017): Indexed Yes
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BFI (2014): BFI-level 2
Scopus rating (2014): SJR 3.514 SNIP 2.483 CiteScore 4.03
Web of Science (2014): Indexed yes
BFI (2013): BFI-level 2
Scopus rating (2013): SJR 3.266 SNIP 2.466 CiteScore 4.36
ISI indexed (2013): ISI indexed yes
BFI (2012): BFI-level 2
Scopus rating (2012): SJR 3.2 SNIP 2.289 CiteScore 4.3
ISI indexed (2012): ISI indexed yes
BFI (2011): BFI-level 2
Scopus rating (2011): SJR 3.203 SNIP 2.213 CiteScore 4.32
ISI indexed (2011): ISI indexed yes
Mobile Phones as Cognitive Systems

Driven by the ubiquitous availability of data and inexpensive data storage, our ability to sense human beings has increased dramatically. Big data has permeated the public discourse and led to surprising insights across the sciences and the humanities. This dissertation presents research on expanding our capabilities in collecting, handling, processing, and using data collected about human beings to create an integrated view of social systems. The goal of the thesis has been threefold.

The first part of the thesis focuses on the need, design, and implementation of large-scale sensor-driven human data collection studies. Social networks can be measured with high resolution and on multiple channels, such as face-to-face meetings, social networks, or phone calls, in order to generate a more comprehensive picture of social systems. The largest study to date measuring large-scale social system—the Copenhagen Networks Study—is described, together with motivation and challenges of the deployment. Preliminary results are presented, indicating how a possibly biased and incomplete picture can be generated when data are collected from a single channel and with a low resolution, thus emphasizing the importance of the proposed approach and deployed implementation.

The second part of the thesis deals with expanding our capabilities to sense the cognitive and emotional state of the users through development of a system for mobile brain imaging—the Smartphone Brain Scanner. A developed framework allows for EEG data collection and processing. It also provides the ability to build end-user applications on top of raw data and extracted features using off-the-shelf and custom-built neuroheadsets and mobile devices, thereby potentially becoming another channel in integrated human sensing. The motivation for creating such system is presented, advanced data processing—3D source reconstruction—is explained, and applications and use-cases are discussed.

In the third part, the privacy issues surrounding the handling of such sensitive behavioral and biomedical data are investigated. A comprehensive review of best privacy practices in sensor-driven human data collection is presented and recommendations for practitioners are made. Based on this review and experiences with the Copenhagen Networks Study and the Smartphone Brain Scanner, the concept of Living Informed Consent is presented, which postulates larger participant control over collected data for the benefit of users, researchers, and society at large. The same privacy principles are applied to a personal neuroinformatics context, resulting in a proposed new approach to sensitive EEG data handling.

General information
State: Published
Organizations: Department of Applied Mathematics and Computer Science, Cognitive Systems
Authors: Stopczynski, A. (Intern), Larsen, J. E. (Intern)
Number of pages: 292
Publication date: 2015
Temporal fidelity in dynamic social networks

It has recently become possible to record detailed social interactions in large social systems with high resolution. As we study these datasets, human social interactions display patterns that emerge at multiple time scales, from minutes to months. On a fundamental level, understanding of the network dynamics can be used to inform the process of measuring social networks. The details of measurement are of particular importance when considering dynamic processes where minute-to-minute details are important, because collection of physical proximity interactions with high temporal resolution is difficult and expensive. Here, we consider the dynamic network of proximity-interactions between approximately 500 individuals participating in the Copenhagen Networks Study. We show that in order to accurately model spreading processes in the network, the dynamic processes that occur on the order of minutes are essential and must be included in the analysis.
We study six months of human mobility data, including WiFi and GPS traces recorded with high temporal resolution, and find that time series of WiFi scans contain a strong latent location signal. In fact, due to inherent stability and low entropy of human mobility, it is possible to assign location to WiFi access points based on a very small number of GPS samples and then use these access points as location beacons. Using just one GPS observation per day per person allows us to estimate the location of, and subsequently use, WiFi access points to account for 80% of mobility across a population. These results reveal a great opportunity for using ubiquitous WiFi routers for high-resolution outdoor positioning, but also significant privacy implications of such side-channel location tracking.
This paper describes the deployment of a large-scale study designed to measure human interactions across a variety of communication channels, with high temporal resolution and spanning multiple years—the Copenhagen Networks Study. Specifically, we collect data on face-to-face interactions, telecommunication, social networks, location, and background information (personality, demographics, health, politics) for a densely connected population of 1,000 individuals, using...
state-of-the-art smartphones as social sensors. Here we provide an overview of the related work and describe the motivation and research agenda driving the study. Additionally, the paper details the data-types measured, and the technical infrastructure in terms of both backend and phone software, as well as an outline of the deployment procedures. We document the participant privacy procedures and their underlying principles. The paper is concluded with early results from data analysis, illustrating the importance of multi-channel high-resolution approach to data collection.

General information
State: Published
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Web of Science (2016): Indexed yes
BFI (2015): BFI-level 1
Scopus rating (2015): SJR 1.427 SNIP 1.136 CiteScore 3.32
Web of Science (2015): Indexed yes
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Scopus rating (2014): SJR 1.559 SNIP 1.148 CiteScore 3.54
Web of Science (2014): Indexed yes
BFI (2013): BFI-level 1
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Scopus rating (2012): SJR 1.982 SNIP 1.156 CiteScore 4.15
ISI indexed (2012): ISI indexed yes
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BFI (2011): BFI-level 1
Scopus rating (2011): SJR 2.425 SNIP 1.233 CiteScore 4.58
ISI indexed (2011): ISI indexed no
Web of Science (2011): Indexed yes
BFI (2010): BFI-level 1
Scopus rating (2010): SJR 2.705 SNIP 1.178
Web of Science (2010): Indexed yes
BFI (2009): BFI-level 1
Scopus rating (2009): SJR 2.614 SNIP 1.046
Web of Science (2009): Indexed yes
BFI (2008): BFI-level 1
Scopus rating (2008): SJR 2.506 SNIP 1.006
Web of Science (2008): Indexed yes
Smartphones as pocketable labs: Visions for mobile brain imaging and neurofeedback

Mobile brain imaging solutions, such as the Smartphone Brain Scanner, which combines low cost wireless EEG sensors with open source software for real-time neuroimaging, may transform neuroscience experimental paradigms. Normally subject to the physical constraints in labs, neuroscience experimental paradigms can be transformed into dynamic environments allowing for the capturing of brain signals in everyday contexts. Using smartphones or tablets to access text or images may enable experimental design capable of tracing emotional responses when shopping or consuming media, incorporating sensorimotor responses reflecting our actions into brain machine interfaces, and facilitating neurofeedback training over extended periods. Even though the quality of consumer neuroheadsets is still lower than laboratory equipment and susceptible to environmental noise, we show that mobile neuroimaging solutions, like the Smartphone Brain Scanner, complemented by 3D reconstruction or source separation techniques may support a range of neuroimaging applications and thus become a valuable addition to high-end neuroimaging solutions.
The Smartphone Brain Scanner: A Portable Real-Time Neuroimaging System

Combining low-cost wireless EEG sensors with smartphones offers novel opportunities for mobile brain imaging in an everyday context. Here we present the technical details and validation of a framework for building multi-platform, portable EEG applications with real-time 3D source reconstruction. The system – Smartphone Brain Scanner – combines an off-the-shelf neuroheadset or EEG cap with a smartphone or tablet, and as such represents the first fully portable system for real-time 3D EEG imaging. We discuss the benefits and challenges, including technical limitations as well as details of real-time reconstruction of 3D images of brain activity. We present examples of brain activity captured in a simple experiment involving imagined finger tapping, which shows that the acquired signal in a relevant brain region is similar to that obtained with standard EEG lab equipment. Although the quality of the signal in a mobile solution using an off-the-shelf consumer neuroheadset is lower than the signal obtained using high-density standard EEG equipment, we propose mobile application development may offset the disadvantages and provide completely new opportunities for neuroimaging in natural settings.

General information
State: Published
Organisations: Department of Applied Mathematics and Computer Science, Cognitive Systems
Authors: Stopczynski, A. (Intern), Stahlhut, C. (Intern), Larsen, J. E. (Intern), Petersen, M. K. (Intern), Hansen, L. K. (Intern)
Number of pages: 10
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Main Research Area: Technical/natural sciences

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Journal: PLoS One
Volume: 9
Issue number: 2
The Strength of the Strongest Ties in Collaborative Problem Solving

Complex problem solving in science, engineering, and business has become a highly collaborative endeavor. Teams of scientists or engineers collaborate on projects using their social networks to gather new ideas and feedback. Here we
bridge the literature on team performance and information networks by studying teams’ problem solving abilities as a function of both their within-team networks and their members’ extended networks. We show that, while an assigned team’s performance is strongly correlated with its networks of expressive and instrumental ties, only the strongest ties in both networks have an effect on performance. Both networks of strong ties explain more of the variance than other factors, such as measured or self-evaluated technical competencies, or the personalities of the team members. In fact, the inclusion of the network of strong ties renders these factors non-significant in the statistical analysis. Our results have consequences for the organization of teams of scientists, engineers, and other knowledge workers tackling today’s most complex problems.

**General information**

State: Published
Organisations: Department of Applied Mathematics and Computer Science, Cognitive Systems, Massachusetts Institute of Technology
Authors: de Montjoye, Y. (Ekstern), Stopczynski, A. (Intern), Shmueli, E. (Ekstern), Pentland, A. (Ekstern), Jørgensen, S. L. (Intern)
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Scopus rating (2015): SJR 2.034 SNIP 1.597 CiteScore 5.3
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Scopus rating (2014): SJR 2.163 SNIP 1.554 CiteScore 4.75
Web of Science (2014): Indexed yes
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ISI indexed (2013): ISI indexed yes
Web of Science (2013): Indexed yes
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Primates Mammalia Vertebrata Chordata Animalia (Animals, Chordates, Humans, Mammals, Primates, Vertebrates) - Hominidae [86215] human common adult, 04500, Mathematical biology and statistical methods, Computational Biology, information network mathematical and computer techniques, member extended network mathematical and computer techniques, self-evaluated technical competency mathematical and computer techniques, statistical analysis mathematical and computer techniques, within-team network mathematical and computer techniques, Mathematical Biology, MULTIDISCIPLINARY, TEAM PERFORMANCE, WEAK TIES, NETWORK STRUCTURE, ORGANIZATIONS, KNOWLEDGE, AUTHOR, WORK, TIME

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Crowds, Bluetooth and Rock’n’Roll: Understanding Music Festival Participant Behavior

In this paper we present a study of sensing and analyzing an offline social network of participants at a large-scale music festival (8 days, 130,000+ participants). We place 33 fixed-location Bluetooth scanners in strategic spots around the festival area to discover Bluetooth-enabled mobile phones carried by the participants, and thus collect spatio-temporal traces of their mobility and interactions. We subsequently analyze the data on two levels. On the micro level, we run a community detection algorithm to reveal a variety of groups the festival participants form. On the macro level, we employ an Infinite Relational Model (IRM) in order to recover the structure of the social network related to participants’ music preferences. The obtained structure in the form of clusters of concerts and participants is then interpreted using meta-information about music genres, band origins, stages, and dates of performances. We show that most of the concerts clusters can be described by one or more of the meta-features, effectively revealing preferences of participants (e.g. a cluster of US bands) and discuss the significance of the findings and the potential and limitations of the used method. Finally, we discuss the possibility of employing the described method and techniques for creating user-oriented applications and extending the sensing capabilities during large-scale events by introducing user involvement.

General information
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Organisations: Department of Applied Mathematics and Computer Science, Cognitive Systems
Authors: Larsen, J. E. (Intern), Sapiezynski, P. (Intern), Stopczynski, A. (Intern), Mørup, M. (Intern), Theodorsen, R. (Ekstern)
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Electronic versions: 1306.3133v2.pdf
Source: dtu
Source-ID: n:oat:DTIC-ART:arxiv/388019930::36135
Publication: Research - peer-review › Article in proceedings – Annual report year: 2013

Crowds, Bluetooth, and Rock’n’Roll: Understanding Music Festival Participant Behavior

In this paper we present a study sensing and analyzing an offline social network of participants at a large-scale music festival attended by 130,000+ participants, and featuring eight days of musical program on 6 stages. Spatio-temporal traces of participant mobility and interactions were collected from 33 Bluetooth scanners placed in strategic locations at the festival area to discover Bluetooth-enabled mobile phones carried by the participants. We employed an Infinite Relational Model (IRM) in order to analyze the collected data and to recover the structure of the network related to participants' music preferences. The obtained structure in the form of clusters of concerts and participants is then interpreted using meta-information about music genres, band origins, stages, and dates of the performances. We show that the concerts' clusters can be described by one or more of the meta-features, effectively revealing preferences of participants. Finally, we discuss the possibility of employing the described method and techniques for creating user-oriented applications and extending the sensing capabilities during large-scale events by introducing user involvement.

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Main Research Area: Technical/natural sciences
Workshop: 1st ACM international workshop on Personal data meets distributed multimedia (PDM 2013), Barcelona, Spain, 22/10/2013
Participatory Bluetooth Sensing: A Method for Acquiring Spatio-Temporal Data about Participant Mobility and Interactions at Large Scale Events

Acquisition of data to capture human mobility and interactions during large-scale events is a challenging task. In this paper we discuss a mobile sensing method for mapping the mobility of crowds at large scale events using a participatory Bluetooth sensing approach. This non-invasive technique for collecting spatio-temporal data about participant mobility and social interactions uses the capabilities of Bluetooth capable smartphones carried by participants. As a proof-of-concept we present a field study with deployment of the method in a large music festival with 130,000 participants where a small subset of participants installed Bluetooth sensing apps on their personal smartphones. Our software module uses location and Bluetooth scans to utilize smartphones as provisional scanners that are present with higher frequency in regions with high density of participants. We discuss the initial results obtained and outline opportunities and challenges introduced by this methodology along with opportunities for future pervasive systems and applications.

General information
State: Published
Organisations: Department of Applied Mathematics and Computer Science, Cognitive Systems, Technical University of Denmark
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Main Research Area: Technical/natural sciences
Conference: IEEE International Conference on Pervasive Computing and Communications (PERCOM 2013), San Diego, CA, United States, 18/03/2013 - 18/03/2013
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Source: dtu
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Publication: Research - peer-review › Article in proceedings – Annual report year: 2013

Spatio temporal media components for neurofeedback
A class of Brain Computer Interfaces (BCI) involves interfaces for neurofeedback training, where a user can learn to self-regulate brain activity based on real-time feedback. These particular interfaces are constructed from audio-visual components and temporal settings, which appear to have a strong influence on the ability to control brain activity. Therefore, identifying the different interface components and exploring their individual effects might be key for constructing new interfaces that support more efficient neurofeedback training. We discuss experiments involving two different designs of neurofeedback interfaces and suggest further research to clarify the influence of different audiovisual components and temporal settings on neurofeedback effect.

General information
State: Published
Organisations: Department of Applied Mathematics and Computer Science, Cognitive Systems, Language-Based Technology
Authors: Jensen, C. B. F. (Intern), Petersen, M. K. (Intern), Larsen, J. E. (Intern), Stopczynski, A. (Intern), Stahlhut, C. (Intern), Ivanova, M. G. (Intern), Andersen, T. (Intern), Hansen, L. K. (Intern)
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Main Research Area: Technical/natural sciences
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A Cross-Platform Smartphone Brain Scanner

We describe a smartphone brain scanner with a low-cost wireless 14-channel Emotiv EEG neuroheadset interfacing with multiple mobile devices. This personal informaticssystem enables minimally invasive and continuous capturing of brain imaging data in natural settings. The system applies an inverse Bayesian framework to spatially visualize the activation of neural sources real-time in a 3D brain model or to visualize the power of brainwaves with specific frequencies. We describe the architecture of the system and discuss initial experiments.

General information
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Organisations: Cognitive Systems, Department of Informatics and Mathematical Modeling
Authors: Larsen, J. E. (Intern), Stopczynski, A. (Intern), Stahlhut, C. (Intern), Petersen, M. K. (Intern), Hansen, L. K. (Intern)
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Publication: Research - peer-review › Paper – Annual report year: 2012

An Evaluation of EEG Scanner's Dependence on the Imaging Technique, Forward Model Computation Method, and Array Dimensionality

EEG source reconstruction involves solving an inverse problem that is highly ill-posed and dependent on a generally fixed forward propagation model. In this contribution we compare a low and high density EEG setup’s dependence on correct forward modeling. Specifically, we examine how different forward models affect the source estimates obtained using four inverse solvers Minimum-Norm, LORETA, Minimum-Variance Adaptive Beamformer, and Sparse Bayesian Learning.

General information
State: Published
Organisations: Cognitive Systems, Department of Informatics and Mathematical Modeling, Convex Imaging
Authors: Stahlhut, C. (Intern), Attias, H. T. (Ekstern), Stopczynski, A. (Intern), Petersen, M. K. (Intern), Larsen, J. E. (Intern), Hansen, L. K. (Intern)
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Bibliographical note
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Get Mobile – The Smartphone Brain Scanner
This demonstration will provide live-interaction with a smartphone brain scanner consisting of a low-cost wireless 14-channel EEG headset (Emotiv Epoc) and a mobile device. With our system it is possible to perform real-time functional brain imaging on a smartphone device, including stimulus delivery, data acquisition, logging, brain state decoding, and 3D visualization of the cortical EEG sources. Implementation of the smartphone brain scanner is based on the Qt framework and benefits from the cross-platform support of multiple hardware platforms (smartphones, tablet devices, netbooks and PCs) that are based on Linux operating systems. Thus our system runs on multiple platforms, including Maemo/MeeGo based smartphones, Android-based smartphones and tablet devices.

General information
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Organisations: Cognitive Systems, Department of Informatics and Mathematical Modeling
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Training your brain on a tablet

General information
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A Smartphone Interface for a Wireless EEG Headset with Real-Time 3D Reconstruction
We demonstrate a fully functional handheld brain scanner consisting of a low-cost 14-channel EEG headset with a wireless connection to a smartphone, enabling minimally invasive EEG monitoring in naturalistic settings. The smartphone provides a touch-based interface with real-time brain state decoding and 3D reconstruction.

General information
State: Published
Organisations: Cognitive Systems, Department of Informatics and Mathematical Modeling
Authors: Stopczynski, A. (Intern), Larsen, J. E. (Intern), Stahlhut, C. (Intern), Petersen, M. K. (Intern), Hansen, L. K. (Intern)
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Memphis, TN, USA, October 9-12, 2011 Proceedings, Part II
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Demonstration: A smartphone 3D functional brain scanner

We demonstrate a fully portable 3D real-time functional brain scanner consisting of a wireless 14-channel 'Neuroheadset' (Emotiv EPOC) and a Nokia N900 smartphone. The novelty of our system is the ability to perform real-time functional brain imaging on a smartphone device, including stimulus delivery, data acquisition, logging, brain state decoding, and 3D visualization of the cortical EEG sources. Custom-made software realized in Qt has been implemented on the phone, which allow for either the phone to process the EEG data locally or transmit it to a server when more advanced machine learning tools are preferred. Source localization is implemented locally on the phone with a 3D brain model consisting of 1,028 vertices and 2,048 triangles stored in the mobile application.

Our system design benefits from the possibility of being able to integrate with multiple hardware platforms (smartphones, tablet computers, and netbooks) that are based on Linux operating systems.

General information
State: Published
Organisations: Department of Applied Mathematics and Computer Science, Cognitive Systems
Authors: Stahlhut, C. (Intern), Stopczynski, A. (Intern), Larsen, J. E. (Intern), Petersen, M. K. (Intern), Hansen, L. K. (Intern)
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Mobile Context Toolbox - An Extensible Context Framework for the Maemo Platform

In this paper we describe an open framework utilizing sensors and application data on the Maemo mobile platform enabling rapid prototyping of context-aware mobile applications. The framework has an extensible layered architecture allowing new hardware and software sensors and features to be added to the context framework. We present initial results from in-the-wild experiments where contextual data was acquired using the tool. In the experiments 6 participants were using a Nokia N900 mobile phone continuously with a logger application for an average of 33 days. The study has provided valuable insights into human behavior in terms of places visited, people met, etc. Moreover, it has provided useful insights into platform issues of the system deployed in real-life usage situations, including the stability and power consumption.

General information
State: Published
Organisations: Cognitive Systems, Department of Informatics and Mathematical Modeling, Technical University of Denmark
Authors: Stopczynski, A. (Intern), Larsen, J. E. (Intern), Skomial, L. (Ekstern)
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Smartphones Get Emotional: Mind Reading Images and Reconstructing the Neural Sources

Combining a 14 channel neuroheadset with a smartphone to capture and process brain imaging data, we demonstrate the ability to distinguish among emotional responses reflected in different scalp potentials when viewing pleasant and unpleasant pictures compared to neutral content. Clustering independent components across subjects we are able to remove artifacts and identify common sources of synchronous brain activity, consistent with earlier findings based on conventional EEG equipment. Applying a Bayesian approach to reconstruct the neural sources not only facilitates disentanglement of emotional responses but may also provide an intuitive interface for interacting with a 3D rendered model of brain activity. Integrating a wireless EEG set with a smartphone thus offers completely new opportunities for modeling the mental state of users as well as providing a basis for novel bio-feedback applications.
Projects:

**Mobile Phones as Cognitive Systems**

Technical University of Denmark  
Period: 01/04/2011 → 05/09/2014  
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