**UNSAID: a Universal Systemfor Auto-Detecting Cognitive Impairments**

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Keywords: universal design, cognitive disability, ICT, auto-detection, interactive systems

**Introduction**

Under Article 4 of the United Nations Convention on the Rights of Persons with Disabilities, the Norwegian government has an obligation to “undertake or promote research and development of universally designed goods, services, equipment and facilities” and “undertake or promote research and development of, and to promote the availability and use of new technologies, including information and communications technologies”. Since 2009, service providers in Norway have an obligation to ensure universal design of ICT solutions, including interactive systems such as services provided over the web or via mobile apps. These human rights aims and legal obligations are complemented bythe efforts of disability rights organizations and Universal Design and Human Computer Interaction experts who propose that all software and devices etc. should be usable by everyone to the greatest extent possible.

While the goal of achieving universally designed ICT systems has yet to be fully realised, incremental progress has been made enabling persons with mobility and sensory disabilities to access and use ICT. While a “digital divide” still exists that limits persons with mobility and sensory disabilities from enjoying ICT on an equal basis with others, a new digital divide is emerging as technology developers, businesses and advocates struggle to provide ICT that is usable by persons with cognitive disabilities. Persons with cognitive disabilities, including autism, intellectual and developmental disabilities, cerebral palsy, traumatic brain injury, post-traumatic stress disorder, Alzheimer’s disease, dyslexia, learning disorders and print-related disabilities, experience a wide range of individual differences in access to and use of ICT. Often cognitive disabilities coexist with sensory and physical impairments and change over time. In addition, designing ICT to be usable by persons with cognitive disabilities can result in an interface that is no longer optimal for a person without cognitive impairments. Thus, user-oriented flexibility and adaptation are required to ensure the usability of ICT specifically for persons with cognitive disabilities– including situational disabilities such as temporary distractions or momentary lapses of memory – and the universal design of ICT more broadly.

**OBJECTIVE**

First, this proposal aims to investigate the feasibility of developing an interactive system based on existing web-based or mobile app technologiesthat will automatically detect if a user has a cognitive disability and if such a detection is made, then the system automatically adjusts or modifies the interaction to accommodate that user’s disability.

This would benefit all Norwegian government agencies and administrative departments that provide public services via the web or mobile appsas well as the broader business community and it supports the government’s commitment to achieving universally designed ICT and an information society that is for everyone (Norwegian Ministry of Children and Equality, 2009). In addition, it will benefit HiOA by continuing to develop and strengthen interdisciplinary cooperation and build capacity in the research and development of universally designed ICT.

We propose to investigate the feasibility of developing an auto-detection system by asking, “To what extent can the behaviour manifested by a user give an interactive system accurate clues regarding the person’s impairment?” Some examples of how this could operate in practice include using a camera to detect impairments by means of observation,analysing key strokes and errors for possible information, and using biometric sensors embedded in smart phones and “wearable technology” to identify indicators of cognitive stress.

Second, this proposal aims to ensure that the project’s technological solutions have the opportunity to achieve broader market adoption. This objective additionally relates to the project’s approach to Responsible Research and Innovation (see section on KEY PERSPECTIVES AND COMPLIANCE WITH STRATEGIC DOCUMENTS). We aim to investigate the potential opportunities that an auto-detection system may provide for ensuring universal design of ICT through the adaptation of digital content. In addition, an auto-detection system has the potential to enhance the market value of digital content by making it usable for a wider population. However, adapting digital content necessitates an examination of copyright and other intellectual property laws, especially considering emerging trade agreements such as the Transatlantic Trade and Investment Partnership.

Copyright and other intellectual property laws aim to protect the rights of digital content creators to publish and distribute their creative works. Therefore, we propose to examine how copyright limitations and exceptions may be used to ensure the market adoption of UNSAID’s technological solutions. This analysis will additionally take into account international harmonization efforts currently underway in the European Union, United Nations and within international organizations such as the World Intellectual Property Organization and World Wide Web Consortium.

The analysis of copyright limitations and exceptions will act as the foundation for promoting a national policy framework for ensuring universal design and the rights of digital content creators. This framework will act as a basis for providing policy recommendations aimed at Norwegian public and private sector organizations.

Third, this project aims to strategically disseminate our research results. This aim is detailed further under PROJECT DISSEMINATION.

**BACKGROUND**

Research onICT auto-detection and -personalizationfor persons with disabilities has only just begun to emerge. In 2011, the EU funded Cloud4All, a research consortium that aimed to develop a Cloud-based auto-personalization system that enables persons with disabilities to automatically customize the interface of a variety of ICT for their needs and preferences (Cloud4All, 2015a). This three year research project resulted in a prototype for an auto-personalization application, compatible with 22 different devices, platforms and applications. In 2015, the US Department of Education funded a five-year, 20 million USD project to implement the Cloud4All prototype as part of a pilot project involving 15,000 users(Cloud4All, 2015b). In addition, the Norwegian Research Council recently funded a project,UDiAide, led by the Norwegian Computing Center (NR), which will examine, among other things, adaptive interfaces in working life.

While these projects have advanced research in automatically personalizing user interfaces for the needs and preferences of persons with sensory and motor disabilities, research has yet to substantively investigate the auto-detection and -personalization of user interfaces for persons with cognitive disabilities.UNSAID aims to extend preliminary research on auto-detection and –personalization for persons with cognitive disabilities by investigating the feasibility of auto-detection and –personalization of a user interface for persons with cognitive disabilities.

Research by Hayes, Abendroth, Adami,Pavel, Zitzelbergerb and Kaye (2008) monitored elderly individuals in their homes over a period of time. One group had mild cognitive impairment (MCI) and the control group did not have MCI. Their aim was to discover if such monitoring of activities in the home could give an indicator regarding the onset or deterioration of MCI. They found that the technique of installing wireless sensors in the home was potentially unobtrusive and led to reliable results. This research is a useful proof of concept for our proposed auto-detection system since Hayes et al. (2008) demonstrates that using technology to monitor individuals over time can give useful information about the onset or deterioration of MCI.

A similar concept was explored by Kaye, Maxwell, Mattek,Hayes,Dodge,Pavel,Jimison,Wild,Boise,and Zitzelberger(2011), where the authors looked at installing unobtrusive sensors in the homes of elderly patients with the aim of assessing aging etc.

Furthermore in another study by Dwolatzky, Whitehead, Doniger, Simon, Schweiger, Jaffe and Chertkow (2003) an evaluation of a computer based test system for detecting cognitive impairments was conducted. The authors concluded, based on empirical research, that the software was able to provide quite accurate results. However, the main issue with this kind of software is that it requires users to submit to a series of tests, where the results of these are aggregated to reach a conclusion about cognitive impairment of the user. This kind of testing, while useful in a ‘medical’ context, would not be useful or appropriate for interactive systems used in consumer-oriented technologies.

There have also been efforts at detecting dyslexia automatically. One example is a US patent for automatic detection of dyslexia filed by Pavlidis(1989). This used bespoke equipment to ‘read’ eye movements etc. However, while the ideas were good, the requirement of special equipment would not be suitable for an everyday type of interactive system which would be potentially used by anyone.

In a more recent body of work, researchers have begun to explore computerized assessment of cognitive and mental health related conditions. For example, Gutman, Moskovic and Jeret (2015), investigated the use of computerized testing of cognitive decline in persons with Down’s syndrome and Alzheimer’s disease. According to the authors, the test can be used to reliably quantify cognitive function over time. In a behavioural study of persons with depression, Saeb et al. (2015)explored whether and to what extent mobile phone sensors could be used to detect behaviours linked to depressive symptoms. The authors argue that phone sensors offer the opportunity to monitor mental health conditions such as depression. In another study by Sikka et al. (2015), the authors developed a prototype for automatically detecting and assessing pain in children. The authors argue that through “computer vision” and machine learning, software programmes can assess and measure pain using facial recognition. Finally, Rello (2014), investigated the use of computer based systemsas a means for suggesting synonyms for difficult words. This was based on the knowledge that those with dyslexia will have an easier time reading a body of text that uses simpler words and other aids, e.g. certain fonts are known to be better for dyslexic readers etc. The authors tested a type of ereader with some of these concepts allowing a user to select certain dyslexic-friendly options. However, this work did not examine the option of automatic detection of impairments and then subsequent automatic adaptation of the user’s interaction.

UNSAID uses research on assessing cognitive and mental health conditions as a point of departure for exploring an auto-detection and –personalization system for persons with cognitive disabilities. Specifically, UNSAID uses research from medicine and rehabilitation science as a basis for examining the feasibility and prospective benefits of an auto-detection and –personalization system for removing barriers to using ICT for persons with cognitive disabilities.

**RESEARCH METHODS**

1. We would begin by conducting a technical feasibility study for determining the viability of automatic detection of cognitive impairments. The feasibility study would involve three inter-related strands: 1.1. Determining outwardly observable human behaviour linked to a particular cognitive impairment. 1.2. Achieving an automated judgement to be made regarding a particular cognitive impairment with non-specialist hardware and software. 1.3. A fast tailoring of the user interface to accommodate an identified cognitive impairment.
2. Assuming stage 1 provides a positive outcome, we would then employ a prototyping approach to design an appropriate user interface to facilitate the automatic detection of cognitive impairments.
   1. If stage 1 provides a negative outcome, we would then, using a prototyping approach, design a user interface to allow users to quickly tailor the user interface to their own needs.
3. Using qualitative techniques we would conduct an evaluation of the prototype(s). The aim of the evaluation would be to gather data and evidence for the usability of our design(s), which would feed into future research and development
4. Contiguous with the technical feasibility study, we will conduct a comprehensive policy analysis related to universal design of ICT and intellectual property law and policy. We will regularly use the results of the technical feasibility study and the policy analysis to further inform the development of the project, contribute to dissemination and enhance opportunities and avoid barriers to further technological and market development.

**PROJECT PLAN**

Schedule 2016

|  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Milestone | May | Jun | Jul | Aug | Sep | Oct | Nov | Dec |
| Feasibility Study | X | X | X |  |  |  |  |  |
| Prototype Development |  |  | X | X | X |  |  |  |
| Prototype testing and evaluation |  |  |  |  | X | X | X | X |
| Policy Analyses | X | X | X | X | X | X | X | X |
| Dissemination – conference papers |  |  |  | X | X | X | X | X |
| Dissemination – journal articles |  |  |  |  | X | X | X | X |
| Dissemination – other as indicated in the section on Project Dissemination | X | X | X | X | X | X | X | X |

**PROJECT ADMINISTRATION**

Oslo and Akershus University College of Applied Sciences (HiOA), Faculty of Engineering, Art and Design, Department of Information Technology will be responsible for project management, and will help with guidance expertise and research resources.

**PROJECT ORGANIZATION**

The project will be located at HiOA. To complete the project within 8 months there is a need for these resources.

External resources:

One 100% Research Assistant position for 8 months, starting May 2016.

Additional funding for research equipment, travel and dissemination.

Internal resources:

One 30% position førsteamanuensisfor 8 months starting May 2016.

One 20% position høgskolenlektorfor 8 months starting May 2016.

**KEY PERSPECTIVES AND COMPLIANCE WITH STRATEGIC DOCUMENTS**

This project attempts to adhere to the principles of Responsible Research and Innovation (Von Schomberg, 2013) by maintaining a transparent and interactive process where the project organizers and participants will be mutually responsive to each other regarding ethical acceptability, sustainability and societal desirability of the innovation process and its marketable products.

**Environmental Perspectives**

For this project it is not relevant to take into account environmental factors.

**Ethical Perspectives**

While UNSAID does not involve collecting sensitive or identifiable data, interviews and participant observations will be used to evaluate the UNSAID prototype. We plan to notify the Norwegian Social Science Data Services (NSD) and adhere to Norwegian legislation concerning data privacy and ethical standards of research by obtaining informed consent from participants, and limiting access to and securing participant data.

**Gender, ethnicity and intersectionalityperspectives**

This project seeks to develop ICT usable by the widest possible population i.e.,everyone. It is therefore important that the project considers the interests of both sexes, people with different sexual orientation and gender identities, of different ages, with and without disabilities, with different ethnic origins, language backgrounds and religious affiliations. This project aims to evaluate and assess issues ofintersectionality within the scope of the research methods.

**Compliance with strategic documents**

The project will help increase knowledge about universal design technical solutions, auto-detection requirements, and persons with cognitive disabilities. This is consistent with several key documents:

Constitution, § 100.

Prop. 1 S (2012-2013)

Government's action plan for universal design and accessibility 2009-2013 Norway universally designed by 2025

The road ahead for ICT initiatives in the Research to it, 2013. (Ch. 3.2, 4.1 and 6.1)

NOU 2013:2 Preventing digital value creation (section 6.4. And 7.3)

UN Convention on the Rights of Persons with Disabilities, Articles 4 and 9.

Anti-discrimination and Accessibility Act, §§ 13, 1:04 and 1:06.

World Intellectual Property Organization, Marrakesh Treaty (Norway signatory but not yet in force)

**PROJECT DISSEMINATION**

First and foremost, the results will be used to educate students at the master's program in Universal Design of ICT at Oslo and Akershus University College of Applied Sciences, Faculty of Engineering, Art and Design, Department of Information Technology. In addition, the researchers involved in the project will seek out additional funding e.g., Erasmus+ grants to conduct guest lectures and seminars at universities and research institutions in Europe.

Secondly, our dissemination strategy aims to cooperate with media partners such as NRK e.g., by offering to appear on programs such as Newton TV program or Schrodinger’s Cat. We also aim to provide commentary in national newspapers and to publish research results via www.forskning.no as well as via the HiOA website and social media, e.g., the Faculty of Technology, Art and Design Facebook group, Universal Design of ICT Master’s Facebook group and the personal social media platforms of the researchers involved in the project.

Thirdly, we shall provide opportunities to present the research results for the Norwegian Directorate for Children, Youth and Family Affairs, their subsidiary departments such as the Delta Centre and related organizations such as the UNIKT forum. Furthermore, the results from this study will be communicated to disability organizationse.g., Karde AS, FFO and NFU.

Finally, we aim to disseminate the results via international peer-reviewed journals, for example:

* Universal Access in the Information Society
* Human Computer Studies and Applied Ergonomics
* Scandinavian Journal of Disability Research
* Disability and Rehabilitation: assistive technology Law, Innovation and Technology
* International Journal of Law and Information Technology
* Behavioral Sciences and the Law

We additionally aim to disseminate the results at relevant international conferences, for example:

* Human-Computer Interaction International 2016hcii 2016.
* International ACM Conference on Computers and Accessibility [ASSETS conferences, 2016 (ACM Press)]
* International Conference on Computers Helping People with Special Needs, ICCHP 2016 (Springer)
* Nordic Network on Disability Research (NNDR 2016)
* CHI conferences in 2016 (ACM press)

Lastly, we plan to maintain regular communication with users. It is essential for the project to establish contact with persons with cognitive disabilities, both for conducting qualitative interviews in connection with the research methods and for user testing during the prototype evaluation. It will be an advantage that the project has contact with a heterogeneous group of people with disabilities; both in terms of gender, ethnicity, age, economic status, education, employment, digital literacy, and the type and degree of disability.Relevant informants for the project may be, people with dyslexia, people with cognitive disabilities and elderly people.

**REFERENCES**

Cloud4All. (2015a) The Project, available at <http://www.cloud4all.info/the-project/>

Cloud4All (2015). "$20 million grant powers the Global Public Inclusive Infrastructure." Retrieved 16 December, 2015, from <http://www.cloud4all.info/20-million-grant-powers-game-changing-internet-access-effort/>.

Dwolatzky, Whitehead, Doniger, Simon, Schweiger, Jaffe and Chertkow(2003) Validity of a Novel Computerized Cognitive Battery for Mild Cognitive Impairment, BMC Geriatrics 2003, 3:4.

Gutman, M., et al. (2015). "Computerised cognitive testing of individuals with Down's syndrome and Alzheimer's disease." Journal of Intellectual Disability Research.

Hayesa, T. L, Abendrothb, F, Adami, A, Pavel, M, Zitzelbergerb, T.A, Kaye, J.A. (2008) Unobtrusive Assessment of Activity Patterns Associated With Mild Cognitive Impairment, Alzheimer’s & Dementia 4, p395– 405, Elsevier.

Kaye, J.A., Maxwell, S.A., Mattek, N., Hayes, T.L., Dodge, H., Pavel, M., Jimison, H.B., Wild, K., Boise, L., &Zitzelberger, T.A. (2011). Intelligent Systems for Assessing Aging Changes: Home-Based, Unobtrusive, and Continuous Assessment of Aging, The Journals of Gerontology, Series B: Psychological Sciences and Social Sciences, 66B(S1), i180–i190.

Norwegian Ministry of Children and Equality. (2009). Norway universally designed by 2025 The Norwegian government’s action plan for universal design and increased accessibility 2009-2013: Norwegian Ministry of Children and Equality.

Pavlidis, G. (1989) Method and Means for Detecting Dyslexia, US 4889422 A.

Rello, L. (2014) DisWebxia A Text Accessibility Model for People With Dyslexia, PhD Thesis, UniversitatPompeuFabra, Barcelona, Spain.

Saeb, S., et al. (2015). "Mobile phone sensor correlates of depressive symptom severity in daily-life behavior: an exploratory study." Journal of medical Internet research 17(7).

Sikka, K., et al. (2015). "Automated assessment of children’s postoperative pain using computer vision." Pediatrics 136(1): e124-e131.

Von Schomberg, Rene ( 2013). "A vision of responsible innovation". In: R. Owen, M. Heintz and J Bessant (eds.) Responsible Innovation. London: John Wiley