IN5620 Lecture notes 29 August 2024 – Universal Design and AI

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Note: This document will be revised for legibility and clarity. Please do not hesitate to send feedback about the document, info about errors, suggestions for improvement and so forth. I hope to revise and improve this text iteratively (of course without extending it too much - or adding new sections), in the same way as you will do with your individual assignment and the group assignment. Since the first version of the course in 2018 yearly revisions have been made;)

1 Introduction

"Kunstig intelligens: Fare eller fremgang for likestillingen?/Artificial intelligence – danger or progress?" This was the theme for the 2020 annual conference by LDO (Likestillingsombudet - Equality and Anti-Discrimination Ombud). In what ways can AI and autonomous technologies contribute to making our society fairer and more inclusive? In what ways can AI be a driver that excludes people from participation in new ways? What new barriers to inclusion and involvement emerge – and what possibilities for inclusion and participation emerge with AI and autonomous systems?

AI and Universal Design are hence discussed politically, on the societal level, macro level today. What challenges and threats do AI pose for equality, inclusion and anti-discrimination? In what ways can we meet the challenges that arise? What opportunities arise? Will for example digital tools in general, and AI-infused or AI-powered tools specifically make participation in schools more or less inclusive than before? And in what ways? For individuals using and interacting with technologies (micro level), for groups and organsiations (meso level), and for society in general (macro level).

Diversity, Inclusion and Universal Design are important concerns when working with systems. In what way can the system we are working with include people - and in what ways does it exclude? Which new barriers to use and participation are made greater, and which are reduced?

This lecture will discuss these three questions:

1. What *challenges* are there when it comes to AI and Universal Design?
2. What *opportunities* does AI provide for inclusion?
3. What are our challenges in this area (students, teachers, practitioners in HCI/Informatics), given our central role in human-centred/user-centred/usability/participatory design? What can we do?

These three questions are broad. We start with some background on Universal Design.

2 Universal Design

Universal Design is concerned with questions concerning inclusion. There are many ways to talk about inclusion when developing, testing and deploying systems. Both on the individual, micro-level, organizational or meso-level and the macro level - the society. Inclusion, discrimination and fairness are often high on the agenda when discussing ethics; such as in this FATE framework (from the book Interaction Design; beyond human computer interaction by by Sharp Rogers and Preece (5th edition)):

Fairness: Is it fair, is data handled fair, without discrimination?
Accountability: Is it correct, valid?
Transparency: Is it visible to the user what is going on, how decisions are made?
Explainability: Explanations, is it possible to understand by us humans?

Another framework is proposed by Jutta Treviranus; presented in her thesis: *"The three dimensions of inclusive design: A design framework for a digitally transformed and complexly connected society."* The three dimensions of the framework are:

1. Recognise, respect, and design for *human uniqueness and variability*.
2. Use inclusive, open & transparent processes, and co-design with people who have a *diversity of perspectives*, including people who can't use or have difficulty using the current designs.
3. Realise that you are designing in a complex adaptive system.

Here in Norway, and in Europe, we have a long history of working with fairness and inclusion; both of the built environment, of products and services. As more and more environments, products and services are digital - or in part digital, ICT and inclusion become increasingly important.

The umbrella term here in Norway is "Universell Utforming" or in short UU. Universal Design (UD) is the English term for this. In other parts of the world terms like Inclusive Design (ID), barrier-free design, design for all - and accessible design are applied. Universal Design is both discussed on the macro level (politics, policies and UN for example), meso level (organisations and domains), micro level (the individual use of ICT).

UD is about conditions and possibilities for the inclusion of all people. An aim when making any new systems or functionality is that the "new" systems are not creating new barriers for users, and the barriers that already exist shall be reduced. UD principles are operationalized

for certain technologies today, such as web technologies. We all know the WCAG (Web Content Accessibility Guidelines) standard by WAI (Web Accessibility Initiative) at the W3C (World Wide Web consortium), that are used as guidelines for ensuring the accessibility of services, applications and content on the net.

The four principles within WCAG are:

1. Perceivable: Information and user interface components must be presentable to users in ways they can perceive.
2. Operable. User interface components and navigation must be operable.
3. Understandable: Information and the operation of user interface must be understandable.
4. Robust: Content must be robust enough that it can be interpreted by a wide variety of user agents, including assistive technologies.

These guidelines are used during the design and evaluation of systems to ensure that systems are available to as many users as possible, without special adaptation or aid (hjelpemidler), in as many contexts as possible.

The term “Universal Design” was coined by the architect Ronald Mace. It is a term used for the design of buildings, environments and products so that these are accessible for all. The seven principles that were introduced to make sure buildings and areas are universally designed are:

1. Equitable use.
2. Flexibility in use.
3. Simple and intuitive.
4. Perceptible information.
5. Tolerance for error.
6. Low physical effort.
7. Size and space for approach and use.

Ron Mace - and his team - were mostly concerned with the built environment, but these principles have also been applied and used in the area of digital technologies.

WCAG provide specific guidelines for web content; and therefore, more specific than the seven principles above.

UCD (user-centred Design), HCI (Human Computer Interaction), and PD (Participatory Design) are concerned with the human side of computing, and work for inclusion of the user group or population in question. Within these research fields, an attempt is to foreground the “user”, the “human”, the “activities and practices” and the “participants” – and work from there. How to make the technologies “fit” the user and the use activities? How to make the technology usable and useful for this or that user or user group? We may say that Universal Design is in a way inherent to these research fields.

A new EU directive about inclusion is the Web Accessibility Directive (WAD). You can read more about this at Digitaliseringsdirektorated/Digdir/UUtilsynet, and learn about “new” initiatives to get more universal designed services and solutions; such as declarations and

options to report problems/feedback on accessibility questions – in addition to the requirement of texting video material.

The work within UD is often about making sure that people and groups with physical, cognitive or motor disabilities (blind, deaf, wheelchair users) etc are included and not excluded. However, the idea - and ideals behind UD is broader. For example, situational disability (tired users, power outage/pitch dark) etc happens for “all”. And of course, in old age, where body functions and cognitive capacities get reduced most of us get to experience.

There are various perspectives and models of what a “disability I” and may be described as. The social model of disability says that disability is something that is created and emerges in the meeting between citizens and society. Stairs make you disabled in a wheelchair or a baby stroller for example, or you are disabled by a combination of cold weather, gloves and the mobile telephone screen. Diana Saplacan at IfI has worked with this in her PhD project, with the final title: *Situated Abilities: Understanding Everyday Use of ICTs*, where disability hence is described as “situational”. This perspective and model are different from the medical model of disability, where disability is something that you have - or are.

What is peculiar with AI and UD? The are opportunities for including more people, even all! Think of the way that information represented digitally may be represented to the user in so many different ways – voice, visual, tangible. The translation of text to spoken words for example, or the generation of sign language from a spoken word. On the other side, there are opportunities to exclude people when statistics and numbers are crunched about people. There are dilemmas and tensions between UD and AI.

3 Challenge - ways of talking and thinking about machines

We have previously discussed ways of talking about machines that are similar to the way of talk about us humans. For example, both humans and machines “understand” and both humans and machines “learn”. When this is the case, challenges arise in determining whose understanding is “correct”, “true” or “right”? With assistance from Searle and the Chinese Room Argument, we can state that computers do not “really” understand in the same way as humans understand. Nevertheless, the rhetoric of AI – and the language used at specific interfaces is often using the concept “understanding”. Output from speech recognition system may for example state that: “I do not *understand* what that is?” or “Help me to *learn* more about this by providing examples”. These are specific examples of machines that in ways attempt to mimic and pretend they have human qualities like understanding, and that machines engage in human activities like learning.

And this way of talking about the machine is not new. Turing, in the 1936 paper “On computable numbers”, where he described the “computing machine” used words like the machine is “aware of” something for example. He stated the following: “We may compare a man in the process of computing real numbers to a machine which is only capable of a finite number of conditions q1,q2,q3,…qn”. What is going on when a person is doing calculations? Reading symbols, writing symbols and following “rules” or “programs”. In

order to explain the workings of the Turing machine, he then imagined that the machine does very similar operations as we human; read, write and “being aware”….

In what way does this matter? Is it only a manner of speaking?

When things go “wrong”, when errors occur, something is missing or in the way for proceeding – whose understanding is the correct one? The user´s understanding or the system´s “understanding”? Or are they perhaps both correct, but from different perspectives? Or both wrong?

One problem with using the same word “understanding” and “learning” for both the computer and the human is that it is means different things to “understand” and to “learn” in the two instances. Machine learning and understanding is about numbers, input and processing – and not about meaning, emotions and making sense. Human learning and understanding is about meaning, emotions and making sense. It is in a way like comparing cats and automobiles; both are names of “things” in the world, but they are of very different kind.

A traditional model of a computer system is made up of three parts:

- Input: Something is sent “in” to the system by the user.
- Processing: Something is done with the input, calculation/manipulation, in an algorithmic fashion; step by step in a sequence and with a selection of operations.
- Output: Something is sent “out” to the user from the system.

With “traditional” systems, the user has overview of what the input to the system is. What happens when the input to the system is “hidden” from the user? Do you have any example of “smart systems” or “AI” systems that operate in that way? Is it then possible for the user to understand that part of the system, if there is no information about what the input is? If the input to the system is datasets with data you do not know about - or sensors that sense something in the environment that you do not know - issues arise for the user - it is simply not possible to get a grip with what is going on!

When using a traditional text editor, or using a traditional telephone service, there is no need for the user to understand the inner workings of the application, service, CPU, base station, wireless protocols and so forth. If you do not get the correct output when pressing the letter, “K” on the keyboard, or you do not hear the person at the other end of the telephone line, you understand that something is faulty or not working with the technology. What is the difference with AI services that “make decisions” and “predictions” and “suggestions” for you? In many situations it does not really matter - for example perhaps which song is recommended to you from a music service. In other situations, it may matter a great deal - when it comes to admissions to schooling, housing and work. Then most people want to understand the reasons, arguments, decisions, criteria, motivations and situations around decisions that are made

One difference is about ambiguity and predictability. In traditional “non AI” system, there is usually a direct coupling between input and output. You press the letter “K” and this is displayed on the screen. However, when interacting with AI system, there is not necessarily

such direct coupling between input and output. Then the question arise: In what way is it possible for the user to understand this unpredictability? In what way is it possible for the user to determine when something goes wrong?

Everyone who is affected by the introduction of an 'AI service' - should have a real opportunity to understand, criticize and influence the design and use of technology so that it does not compromise with principles of inclusion and universal design. This is a thesis that need some arguments. What are they? If this thesis is not the case, who should understand and criticize and influence? Some “expert” or authorities? Legal experts? Engineers?

To say that “the machine understands” and “the machine learns” may trivialize what is meant by human understanding and human learning. What can we learn from the statement “the machine learns” and “the machine understands me”?

4 Challenge with principles and guidelines

Understanding how to use a computer has traditionally been important in HCI. Heuristics, design and evaluation guidelines are found in the HCI literature for conventional graphical user interfaces and interaction by for example Donald Norman and Ben Shneiderman.

Within Universal Design - similar heuristics and principles are found. In the WCAG 2.1, one of the four principles is: «Understandable», and this is described as:

Information and the operation of user interface must be understandable.

In the Microsoft guidelines for Human AI Interaction, the second guideline is:

Make clear how well the system can do what it can do. Help the user understand how often the AI system may make mistakes.

A question that arises from this is: Is it possible for the designer to know this in advance – what the various user in various use situations and with various user tasks understands? With a diverse user population, how is it possible to ensure that all understand?

What role does user involvement and user participation have in this area?

5 Challenge with numbers, statistics and the human

There are potential threats of AI with respect to «outliers». This topic has been in the press and many public efforts have emerged. Books such as Weapons of Math Destruction (O'Neil, 2017) and Sufiya Ujoma Noble (2018) and Virginia Eubanks (2018) powerfully framed the role of AI in amplifying and demonising poverty and automating racial bias. All three authors highlight the systemic vicious cycles of discrimination experienced by individuals. This happens when general predictions are based on numbers, and categories made up of statistics about human activities and capacities.

“If you are unique (and aren’t we all), numbers are not our friends” (Trevanius) is one statement that needs some explanation. Numbers are potentially very useful for many different purposes within sciences - as well as in everyday life. A meeting starts at 12:15! Or this object is 2103 kilogram, whereas this is 2108 kilogram. Please have a look at the video We Count by Jutta Treviranus.

However, since we humans are all “unique”, there are some challenges of including all the “uniqueness” of humans into numbers.

Jutta Trevanius explain further this uniquness: “.....to recognise the uniqueness of each individual. We are each an irreducible and evolving complex adaptive system of characteristics and needs. This uniqueness and wild, organic diversity have been inconvenient when it comes to designing products, communication, environments, or policies. It defies mass production, mass marketing, mass communication, mass education, as well as simple and straightforward public policies.” Even within one individual, there are idiosyncrasies and differences from situation to situation; after all we are doing a bit different talking and acting here in this lecture here/now compared to 3 am Sunday at a celebration.

When developing systems in general, very often we tend to design for the “majority”, where limited resources are applied to reach a broad population. The 80/20 principle, or the Pareto Principle, where 20 % of the resources is used to reach 80 % effect is well documented in various disciplines.

This is not an inclusive process; since potentially 20 % (or so) of the population is left out. Another possibility is to aim from the start to reach 100 %, and as a process continuously ask “is anybody left out with this solution?”, and if so, address it. This is at the core of Universal Design.

However, this is a challenge when it comes to working with the “average” and modelling probability”, or the “normal” user.

For the argument here, we will invoke every day, basic statistics about the “data” that is the “input” for machine learning algorithms.

Here we come into some basic statistics:

Distribution. Data about a population has a distribution. Often, we mean probability distribution when talking about distributions. The most common is normal distribution (other names Bell curve (looks like a bell) giving a Gauss Curve), Binomial distribution (two outcomes, true and false) and Uniform distribution (throw one dice many times). In probability theory, the normal distribution is a common continuous probability distribution. Normal distributions are often used in the natural sciences. It is also used in social sciences and humanities.

Outliers: This are data points that differs significantly from other data points in a data set about a population. Outliers emerge as a consequence of entering large data sets about phenomenon into a model that represent a specific distribution.

Representations. Data is about something, and often represented by numbers in computers. It is a lot happening from the “real world” to the representation of the real world, or representing aspect of the real world. How happy are you on a scale from 0 to 10? Let's say you answer 7. This number 7 represents the level of happiness for you (when you answered the question, at that particular place, and at that particular time, in that particular situation). Or, a face recognition system determines by a visual representation of your face that you are 3.27 on this happiness scale. Represetations are proxies or indicators, not the “real thing” or the “real phenomenon”.

Average (gjennomsnitt) can be the mean, median, and mode. The "mean" is the "average" we are used to, where we add up all the numbers and then divide by the number of instances. In the list of numbers, the "median" is the "middle" value. You list the numbers in numerical order from smallest to largest in order to find the median. The value that occurs most often is called the “mode”. The average person do not exist.

Standard deviation is a number that tell how measurements for a group are spread out from the average (mean). A high standard deviation means that the numbers are more spread out. A low standard deviation means that most of the numbers are close to the average.

Working with statistics and probability calculations are very valuable for production processes and manufacturing for example. There are some challenges when working to with inclusive design however. Two of the challenge are the notion of the “average” and the notion of the “Normal” in Normal distribution. This may foster comparison of what is above or below the average, as well as what is not-normal or even ab-normal.

"Lies, Damn Lies and Statistics" is the name of episode 21 in the first season of NBC drama *The West Wing.* Many people have used this phrase before, what does it mean? One interpretation is that the use of statistics can be done in many different ways, also for misleading and even lying. What does this old insight imply for interaction with AI and inclusion?

n=1 is another way of saying that each human or user of a system is unique. This is then a challenge when one system is to be developed for a population of n=3.800.000 users!. What are the challenges?

When modelled in statistical models, human traits (exercise, mood, shape, reasoning, navigation activates etc.) get measured and represented in numbers. Outcomes of this is very average, standard deviation - and outliers. How to work with this dilemma?

There is no “final solution” to be found here about inclusion and AI. However, it is about critically asking questions during development of systems, and bringing in a variety of users. Who are excluded if any? Another way is to get to know, and work with both the WCAG principles and the WAD actively. And of course, to be enthusiastic about participation and users’ diversity.

6 Opportunities

Interestingly, the development of AI technologies in current and previous research projects have often focused on inclusion and universal design. For example, is speech synthesis and speech recognition research has been driven by the need of people without vision - in order for them to be able to interact with computers by way of audio and speech. Today, we see many applications and services that are making interacting with digital material more inclusive; by way of various pattern recognition systems such as speech and image recognition.

The MECS project here at IfI is one such example, where we investigated the possible use of robots at home for the elderly living independently at home. A group that potentially can stay longer at home with some help from various AI technologies such as “robots” moving around in the home. The RHYME project is another example, where interfaces and novel interaction mechanism for making and playing music for all was addressed.

Other examples of technologies that “initially” was designed and developed for people that had challenges of using “standard” solutions are:

- Speech synthesis and speech recognition. Audio books for the visually impaired.
- Remote control: To help out with motor impairments.
- Video conference: Used by the visually impaired for assistance.
- Eye tracking/detection: Used as an input for motor-impaired users.

So one part of “AI” and “inclusion” is the positive side for inclusion - where AI technologies are developed, applied and used to include people and users who are else excluded.

If you compare a smiley on a piece of paper – with a smiley on a mobile phone. What differences and similarities are there? In what way is it possible to represent the digitally represented smiley?

What are the opportunities that you see today? The Seeing AI project is one example of newer commercial initiatives that has potential for all. Other projects, applications or services?

7 What can we do – learn more about?

We have addressed two challenges here; the way we talk about machines – and statistics and “normal” distribution. In addition, we had the question:

What is our challenges in this area (students and teachers in HCI/Informatics), given our central role in human-centred/user-centred/usability/participatory design? What can we do?

Continue working with user-centred design! And participatory design! These are two possible answers.

Being aware of “outliers”, being aware of “bias”, and being aware of “probabilities/statistics” when working with AI systems.

Bring awareness to the language we use when talking about machines and the use of machines. And to bring awareness to the potentials and challenges with guidelines and principles for both AI and for UD.

What is your challenge in this area?

Jo