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Human-Data Interaction

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Abstract

The time has come to recognise the emerging topic of *Human-Data Interaction (HDI)*. It arises from the need, both ethical and practical, to engage users to a much greater degree with the collection, analysis, and trade of their personal data, in addition to providing them with an intuitive feedback mechanism. HDI is inherently inter-disciplinary, encapsulating elements not only of traditional computer science ranging across data processing, systems design, visualisation and interaction design, but also of law, psychology, behavioural economics, and sociology. In this short paper we elaborate the motivation for studying the nature and dynamics of HDI, and we give some thought to challenges and opportunities in developing approaches to this novel discipline.

1 Introduction

Recent years have seen an increasing trend toward the collection and use of the so-called *Big Data*. Companies such as Google, Facebook, dunnhumby, and Experian collect and mine vast quantities of personal data, public and private, about us and our activities.¹ Sources of such data include our purchasing habits (on- and off-line), financial data, and communications data (from phone call records to social media content), among others. The trend is complemented by individuals' digitally recording and archiving their life events, e.g., Gemmell *et al.* [17] and the Locker Project [4].

Conversely, there has been a recent growth in the number of applications that directly benefit the users from their own publicly released data: traffic reports on Google Maps, crowd-sourcing road

condition reporting on Waze,² and bus route optimization in Africa based on cell phone data.³

The impact of this data processing is pervasive and wide-ranging – it informs credit ratings, the online advertising industry, and retailing, and it is used in a wide range of other predictions and inferences; from sexual orientation, to voting preference, and even (some claim) likelihood of a divorce. These data are at the heart of most Internet business models, particularly those based on advertising and market intelligence. In fact, the act of data collection has been shown to alter individuals' behaviour [31], reinforcing the need for understanding the interaction between individuals and the information gathered about them.

An ecosystem, often collaborative but sometimes combative, is forming around companies and individuals engaging in use of personal data. Increasingly, we observe concerted or autonomous group actions in reaction to changes in company data policies, e.g., news articles about user reactions to Instagram terms of service; or the knowledge of protest locations in political situations, e.g., [33]. However, the depth and breadth of this data, and the inferences being drawn from it, give rise to a set of interrelated challenges:

- *Were you conscious of all the personal data you signed over last time you signed up for a customer loyalty card?*

As users, we typically do not know how various, wide-ranging and detailed are the data available about us. This raises serious ethical and legal concerns as it makes notions such as “informed consent” effectively meaningless. We need better mechanisms and tools for explaining and elaborating to users the nature and content of these datasets and algorithms.

- *Do you know the uses to which your data are put?*

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¹Note that we use *personal data* to mean both data *about us* and data produced *by us* throughout.

²<http://www.waze.com/>

³<http://www.technologyreview.com/news/514211/african-bus-routes-redrawn-using-cell-phone-data/>

Such uses may be entirely invisible, or more obvious, through targeted adverts; however, the inferences drawn from our personal data are also sometimes wrong – certainly if the adverts shown in the authors’ Facebook news feeds are anything to go by, *mostly* wrong. This can be due to poor quality input data, sometimes itself the output of an inference process, or simply the statistical nature of the inference process analysing the data. However the algorithms cannot know this, and we, the users, frequently do not know when invalid inferences have been drawn. We need ways to enable users to inspect and correct the data held about them and affect the algorithms that are inferring things about them.

- *What would you look for, if you could search through all your data?*

There are thousands of mobile phone contracts, utility tariffs, exercise plans, travel options, fitness regimes and diet plans that we have to choose from throughout our daily lives. Our choices could greatly benefit from novel and intuitive data aggregation, summarisation, analytics and visualisation techniques. Some of the HDI challenges lie at the heart of presenting the individuals with such choices.

As reliance on these systems increases, we believe that people ultimately must be able to utilise their information with privacy-aware analytics and service providers, and take more explicit control over consumption of their data and the information it provides. Unfortunately, viewing the web (and, indeed, the Internet) as a big dataflow engine, all technical work to date has been about using the edges (smart phones, keyboards, eyeballs) as sensors, and the core (datacenters, search, graph processing) as the mine. In contrast, we propose putting the *human* at the centre of the data flows, which requires providing mechanisms for citizens to interact with these systems *explicitly*; hence we adopt the phrase **Human-Data Interaction**.

Sitting in the intersection of multiple disciplines, from computer science, statistics, sociology, psychology, and behavioural economics, we believe that HDI deserves treatment as a distinct topic: after briefly defining the context with which we are concerned (§2), we elaborate on this position in the remainder of this paper discussing what it is and is not (§3), why we think it is interesting (§4), and what we as a community should do about it (§5). We finalise the paper by discussing potential avenues for future research (§6)

2 Data: Big or Small

The term *data* often refers to the numbers, symbols, signals and overall facts representing the status, condition and contextual situation of entities, in a minimally processed and structured form. When it comes to the *size* of the data, systematic collection of large amounts of data predates computers – for example, around 300 BC Euclid’s Data is defined “*to facilitate and promote the method of resolution or analysis*”. However, the *Big Data* phrase in the computing community is often referred to as data that is collected using a variety of *signals* and sources centred on an entity, while being multifaceted in temporal and contextual sense. Within the context of HDI, this gives rise to a number of economic, political, and social implications, beyond the use of this phrase in the context of visualisation, and in addition to technical ones also discussed by Jagadish *et al.* [1].

Previously coined in the specific context of gesture suites for embodied interaction systems [9], we use HDI to refer to analysis of the individual and collective decision that we make and actions we take, as users of online systems, or as subjects of data collection practices. HDI goes beyond the work of, e.g., Dix [13] on the evolving nature of HCI and stimulus-response cognition models behind individuals’ interaction with information. It points to the need to make explicit the link between individuals and the *signals* they emit as various data forms (e.g., location, shopping trends, search terms), as the richness, pervasiveness and impact of these models continues to grow.

Within computer science two distinct aspects of data concern is: the data itself, and the processes involved in using it. The relationship between these is tight-knit, to the extent that some define data in terms that include its eventual purpose and intended use.⁴ Several recent efforts have focused on promotion of *Open Data*: “data that can be freely used, reused and redistributed by anyone – subject only, at most, to the requirement to attribute and share-alike”.⁵ Such data, particularly linked open data, can facilitate individuals personal understanding of their digital footprint. This concept goes hand-in-hand with the open source movement: data and its processing code need to have associated meta data and transparency. Within the HDI discipline, in this paper we focus on the *human understanding* of the data and its processes.

⁴E.g., the ICO key definitions of the Data Protection Act at http://ico.org.uk/for_organisations/data_protection/the_guide/key_definitions.

⁵<http://okfn.org/opendata/>

3 What is HDI?

We deliberately adopt the phrase HDI by analogy with HCI, so as to clearly distinguish between the two. We expand on previous definitions of Human-Data Interaction which were more limited to visualisation. The concern with HDI is not interaction between humans and computers generally, but between humans and the analysis of large, rich personal datasets. HDI overlaps HCI but is not contained within it. Specifically, HDI differs in two important ways:

- We are not dealing with explicit interactions but with more passive scenarios. In HDI we consider people interacting with apparently mundane infrastructure, which they generally do not understand and would rather ignore. Opening up such infrastructure to support such interaction is a challenge that has been faced in other contexts, notably home networking [12, 27].
- The scale of these systems is much bigger than usually considered in interactional studies. Data concerning entire populations is presently stored and analysed in terms of petabyte or quintillion-bytes.

HDI includes the combination of both data, *and* the algorithms used to analyse it. Where this term has previously been used, it has focused on embodied HDI and visual interaction methods with large datasets [16]. Another field closely related to HDI is the study of *privacy*. Again, HDI is distinct but overlapping. Privacy is a particular concern that might be raised here based on what the data is and how it is used. HDI is broader, and is based on understanding the data *out there* about individuals, the ways in which and by whom it is used, and how people might desire and act to influence, and ideally benefit, from the data and its use.

Figure 1 depicts our characterisation of current systems. Analytics is provided as a “black box” within which collated input data is processed as facts in large centralised facilities (data centers). The outputs of this processing then cause actions, which may include feeding inferred facts into subsequent analysis by others. We believe there are two key points in this cycle where greater transparency to and control by subjects is needed.

First, the analytics algorithms themselves must become less opaque – what data are they consuming, what methods are they using to draw inferences. This is often in direct tension with the fact that these processes represent core intellectual property of the companies that implement and run them, and so cannot easily be made public.

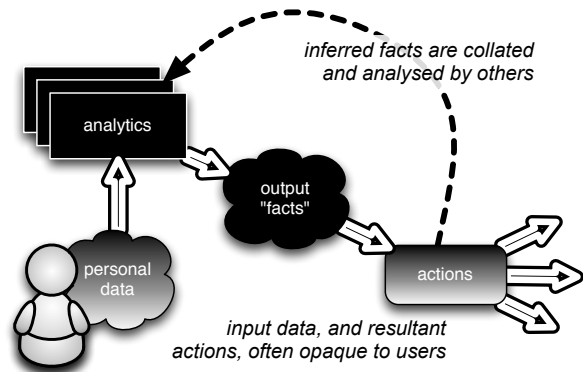


Figure 1: Human Data Interaction. *Personal data* about and by each of us, whether we are aware of it or not, feeds into black-box *analytics* algorithms to infer *facts*, both correct and incorrect. These drive *actions*, whose effects may or may not be visible to us.

Second, subjects need to be given control over the inferences that are drawn and the actions that these inferences inform. These systems are large and complex, and although they have impacts that can affect us all, many of the effects will be positive or insufficiently negative to be noticeable. The problem then becomes how to engage ordinary people with such complex and mostly uninteresting systems.

4 Why is HDI Interesting?

There are two features that make HDI interesting. First, as experiences with different Online Social Networks (OSN) such as Twitter has shown, the impact of the inferences drawn from public personal data can affect the market value of billion dollar corporations, move the use of national infrastructure outside expected parameters, and even topple governments. Second, the inferences drawn from on- and off-line private personal data, such as passive measurement, location, and communications, create a *virtual personality* for each individual. Thus HDI contains this simultaneous mix of two contrasting features: sheer scale and personal richness.

As digital technology becomes ever more tightly embedded in our lives, with the future holding the promise (or threat) of continuous monitoring and data collection (e.g., for health status monitoring), the ethos around the ways we enable individuals to interact with their digital identities only increases in importance. Taking the optimistic view, HDI may bring the dream of *calm technology* [34] into reality by collection and processing the individual’s data

and assessing the feedback from the user interaction with surrounding environment, in ways previously deemed infeasible [29], due to great advances in the field of Machine Learning.⁶ The result is a complex system, with many components interacting and thus posing challenges at many different levels:

- **Visualisation and sense-making.** How are people to make sense of any of such complex, technical systems?
- **Transparency and audit.** What audit trails and information are to be provided to support this?
- **Privacy and control.** How can the resulting audit data be used to enable interaction around control of access to and processing of data?
- **Analytics and commerce.** How can the analysis algorithms that are used, often trade-secret, be made transparent to users while retaining their protected commercial status?
- **Data to knowledge.** How can the vast amount of data be used to benefit the individuals and let the society exploit the wealth of information offered by shared data?

5 What Should We Do About It?

From the preceding discussion, it seems clear HDI is interdisciplinary in nature, and sufficiently interesting to deserve treatment as a distinct topic. But what are the implications of this? In what areas should researchers engage with HDI? Without wishing in any way to pretend that this is an exhaustive list, we now present some of the ways that we see existing domains of study intersecting with HDI.

HCI & Data Visualisation An obvious existing domain that overlaps with HDI, discussed above, is HCI particularly those topics relating to data visualisation. Many of the concepts and datasets that motivate the need for HDI are rather abstract: enabling subjects to interact naturally with their data and the algorithms processing it is an important goal. Examples of existing work in this space include [16, 9] where embodied allegories are used in order to support the design of meaningful Embodied Interactions.

⁶An example of such data-push approaches is the recently launched *Google Now* service <http://www.google.com/landing/now/>

Analytics From an industry perspective, perhaps the most important aspect of personal data use is analytics. The *Big Data* buzzword is the driving force behind interest in this factor, where Big Data is loosely characterised as possessing by the 3 Vs: Volume, Variety, and Velocity [15]. Another contributor to this effect is the growth of Internet of Things (IoT) and the rise in interest in this field, leading to increasing volume of ambient data from our urban environment [35]. As noted in previous sections, a key element of interest to HDI is to ensure subjects are aware of which data they will give up, and of the processing that will be carried out over their data, effectively remaking notions of informed consent. The challenge is to achieve this while respecting and retaining the commercially critical core of many analytics algorithms.

Privacy & Security Lack of strong regulation and policing, coupled with cultural differences in service provision and online behaviour, has resulted in a wave of strong user reactions in response to political events and industrial developments in the *Big Data Analytics* era. In reaction to this trend, individuals, governments, privacy advocates, industry, and regulators have been fiercely fighting their corners concerning collection, usage, trade, and retention of personal information. For example, Facebook's share price was down by over three percent on the day when Instagram temporarily changed its terms of services⁷, due to the reaction of a large number of users who immediately closed their accounts. There has also been a number of correspondences regarding facial recognition technologies and regulatory recommendations and privacy [2]

Recently, researchers have worked on the concept of *usable privacy*, developing a number of theoretical and applied techniques including digital data vaults, e.g., the Personal Container [26], privacy-preserving data collection and surveying methods [14, 19], smart metering [28], and privacy-preserving user profiling and advertising techniques [18, 22]. We need to re-balance individuals' rights without disrupting new business models.

Social Psychology Individuals' decision making can be manipulated in many ways, for example by altering the choices available and the order in which those choices are presented [31]. Interaction with online content is also affected by the way in which information is presented, e.g., the spread of content on social media is known to be a result of the way content reaches individuals [10]. Similarly, Google has used search term analytics to work out how a

⁷<http://www.nasdaq.com/symbol/fb>

flu epidemic is evolving, although such approaches are also subject to false-positives due to hype bias in the news resonating and amplifying observed effects [8]. This is a simple example of the feedback loop between HDI and forecasting algorithms. Even in population scale Big Data industries, the human factors of judging ambiguities and cross-referencing terms across social and cultural boundaries, is still a key element. Human evaluators or raters help Google assess optimisation factors to search algorithm and Twitter uses individuals, referred to as judges, to aid in interpreting the context of search terms in trending topics [3]. The challenge is to apply the tools of fields such as social psychology and computational linguistics to better understand these effects, on-line and at scale [20].

Behavioural Economics People across the world appear happy to give up on a number of personal necessities – including personal hygiene and sex – simply to stay *connected* [32]. Hence the Internet infrastructure’s open, non-discriminatory shared nature has been of central interest to a number of advocacy groups. Changes in access to data often cause Internet activism, sometimes leading into political and regulatory movement, e.g., the 2013 ITU voting case on Internet Governance [21, 30]. Within the digital economy perspective, recent works have shown the different reaction patterns between infrequent users (ineffectiveness of ads) and loyal customers, whose purchasing behaviour can be influenced by paid search adverts [11, 6]. We need to understand how recent behavioural targeting advances to increase the revenue from advertising have affected the personal data collection ecosystem, and the users’ interactions with online content and smartphone applications.

6 Future Directions

Our thesis has been that HDI is worthy of treatment as a distinct topic of research, and we have covered a number of facets of the HDI ecosystem in this review. Though HDI is not necessarily about *Big Data*, it depends indirectly on understanding the potential biases and inaccuracies in Big Data where it concerns people, where the sheer quantity of data is sometimes confused with quality [7]. The current regulatory situation around use of *big* personal data is far from acceptable, a point that bodies such as the EU and the UK’s Parliament are now beginning to respond to.⁸ Ultimately however,

⁸E.g., <http://www.publications.parliament.uk/pa/bills/lbill/2012-2013/0045/amend/ml045-vii.htm>

HDI places humans in their rightful place, not just as stakeholders in this system but at its very centre. Study of HDI thus provides a framework within which to address many related issues, for example:

- developing mechanisms to improve data quality and data processing algorithms, and to give people control over lifetime, scope and visibility of their personal data;
- as a pre-requisite for many such mechanisms, how to make our data available in a *machine-friendly* form so that it can readily be processed by code rather than only inspected visually via webpages; note that challenges here include not only how best to structure and represent such heterogeneous data, but also issues concerning licensing and informed consent in giving others access to our personal data, where we can benefit from releasing such data;
- realising the potentials for a *Personal API*,⁹ enabling one to voluntarily take part in an information marketplace [23, 5];
- reconciliation of such use and control of personal data, with a regulatory push to Open Data,¹⁰
- creation and promotion of novel approaches to use of shared personal data in order to offer insight and information to the individuals and the society as a whole, while respecting their privacy;
- understanding the many complex and subtle ethical and legal issues surrounding use of big personal data, giving meaning to mechanisms such as the right to be forgotten;
- addressing the broader societal implications of having such rich personal data available at scale, able to be gossiped across the globe in milliseconds; in particular, how we can build geo-social controls over visibility of our data to help people avoid offence, embarrassment and worse;
- reworking conceptions of informed consent from its current intolerable state [25], supporting the regulatory push for transparency into value of personal data in the information economy;
- and, ultimately, stopping the downward trajectory of economic value in the information age [24], hence avoiding disproportionate economic power concentrating in the data aggregators.

⁹see also <http://gregmeyer.com/2013/06/10/revisiting-the-api-of-me/>

¹⁰<http://blog.okfn.org/2013/02/22/open-data-my-data/>

The way many services are currently deployed and monetized encourages us all to trade eyeball time for “free” services, resulting in the enormous valuations accorded companies such as Facebook and Google due to the massive quantities of data about us they accumulate. Addressing the challenges given above would go some way towards levelling the playing field between us as the users, who are farmed for our data, and our data overlords who gather and exploit it.

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