Diversity Computing

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Insights

- Existing digital technologies exacerbate the biases of the human mind, inhibiting diversity initiatives
- Diversity Computing is a new framework incorporating innovation in theory, methodology, and technology that embraces diversity and avoids normative ordering.

A neural network for classifying gang crime was presented recently at the "Artificial Intelligence, Ethics and Society" conference. When asked about the potential for such technology to have negative uses, one of the researchers told reporters, "I'm just an engineer," causing an outcry online and in the media. Meanwhile, in an article for the *New York Times*, Farhad Manjoo wrote that 2017 was the year in which it dawned on big tech companies that their digital systems come with real-world responsibility and that 2018 will need to be the year in which they, and we, figure out what that means.

But more is required than responsible innovation. Taking responsibility, we argue, requires a radical reframing of the role of computing in human lifeworlds. We must envisage roles for technology in a desirable future that reflect and promote a better society. This is not just an argument about how people should put existing computational technologies (e.g., social media) to a different use—we claim that what is needed is the *design* of fundamentally new *kinds of computing devices*.

Here we sketch such a vision, called *diversity computing* or *DivComp*, and possible ways to realize it. We outline a transformative theoretical framework, linked to current and emerging technologies, and we share speculative designs as examples of DivComp implementation. Our DivComp scenarios invite and facilitate shared meaning-making between individuals and groups, embracing differences rather than eliminating them, without recourse to normative frameworks. We further propose that a combination of

philosophical and cognitive theory, participatory methodology, and digital innovation should be deployed in trial areas to develop the concepts and artifacts involved.

On Uniformity Computing

Our globalized and networked world has increased our direct contact with people who are overtly different in various ways (skin color, language), bringing along the realization that a broadly shared consensus on universal human values may be an extremely complex, if not fundamentally impossible, goal to achieve. At the same time, a revived individualism emphasizes self-reliance, independent action, and personal freedom over collective responsibility. Together, these present a recipe for social disintegration that we believe DivComp has the power to address (see “Divcomp and Immigration” sidebar). Psychological theory suggests that stereotypes and biases have an adaptive function [1]. They reduce the cognitive resources required to process information about new people and contexts, by providing shortcuts to judgments on which behaviors can be based. We rationalize our subjective experiences by creating models of the social world that we take to be objective. Thus, in DivComp, our goal is not to eliminate human biases, which are both inevitable and frequently useful, but instead to support people to reflect on them, question their presumed objectivity, and challenge their negative effects.

Sidebar 1: DivComp and Immigration

The “othering” of recent immigrant communities fuels prejudice and enables far-right political parties to gain traction. It is evident that the most entrenched anti-immigration sentiments regularly arise in regions not directly affected—i.e., those without significant immigrant communities. To counter the exacerbated fear of the unknown, DivComp devices could enable people from different cultural backgrounds to share parts of their lifeworlds remotely. Facilitating embodied experiences of everyday activities in personal or public spaces can provide first-person perspectives on what makes up another’s sense of identity, including emotional drivers such as anxieties, sense of belonging, or aspirations. These experiences could be shared by connecting directly to other people’s bodily responses—to experience walking in their shoes almost literally—and combining these with self-annotation. Such DivComp-enabled linkage between communities and individuals would be instrumental in challenging prejudice, building mutual respect, and fostering resilience against fear-driven political manipulation.

Instead of allowing for critical reflection on our human practices, contemporary computing technologies serve to reiterate the irrationalities and biases in human thinking, sometimes even exacerbating them beyond control. Image search results reinforce gender stereotypes [2], while autocomplete search forms have been linked to racial prejudice [3] and Twitter chatbots turn racist in under a day. Everyday users of online search engines may believe them to be free of bias, not recognizing that any machine-learning algorithm has inbuilt tacit agendas derived from, for example, the data on which it is trained or the measures it uses to close in on its targets.

Meanwhile, social media creates echo chambers that actively inhibit dialogue between people in different political camps [4]. These stimulate confirmation bias, giving users false impressions, either of gathering a range of perspectives from a broad group, or of being part of a majority consensus. More recently, Paul Lewis wrote for the *Guardian* about how the algorithm that governs progress from one YouTube video to those "up next" has been accused of actively promoting false information and even inciting violence [5].

Lack of diversity in STEM subjects, including computing, may be partly to blame for these phenomena [6]. When the creators of new technologies are similar to each other, they may build devices and software that serve to meet only their needs and not the needs of diverse users. This means that concepts such as accessibility, equality, and cultural sensitivity are tackled as an afterthought, rather than being fundamental in the design process. One solution is to cultivate greater diversity within the team, so technologists are forced to confront and resolve the problems posed by diverse needs and perspectives from the outset.

However, we argue that this solution alone is inadequate. Diversity endeavors already risk being tokenistic, when people are brought into a team specifically to represent their group but are not given the power and influence to make a difference. Expecting any (and every) design team to not just incorporate "diversity" (in the sense of, "some people who are different from each other") but to actively represent all of the groups that might one day use that technology is impossible, without resorting to tokenistic user-design activities. In fact, there is near infinite variety in the human race, in combinations of gender, race, sexual orientation, ethnicity, social class, religious belief, disability, and

age (to name only a few dimensions of diversity). Diversity is inherent in the living world, existing within groups and indeed within individuals, as well as between them. Thought of in this way, no team can ever represent diversity. Moreover, individual differences within teams designing technologies merely extend the range of normative references of those teams; they do not eliminate them altogether. Thus, it is impossible to rely on individuals within a collaborative team to address diversity via representation[1].

Technological advances are often heralded as innovative, even transformative. However, in general, the effect of automation is that often unspoken norms for behavior, which were being *sustained* in ongoing interactions between members of a community, are made *explicit* and thereby *solidified*. Consider an interaction between a customer and a clerk. The rule may be that if the person is late for a certain application (say, a new passport), she can apply again only after another three months. The clerk knows the rule but may decide to break it. "Just this once," they might say. The more technology is involved, the more the space for personal improvisation and problem solving is reduced, if not completely removed.

All these examples illustrate that computing and technology often demand or drive toward uniformity, making it difficult to deal with the inherent diversity of the world. Thus, the success of DivComp not only relies on technological innovation, but also needs careful theoretical reflection to discover and increase ways to enable mutual understanding without inadvertently exacerbating human bias.

The Theory of Diversity Computing

We propose diversity computing devices that will invite people who are different from each other to *participate in an active and reflective process of meaning-making*. In this context, *diversity* refers to the infinite variety in interpersonal settings, rather than to a set of quantifiable or observable characteristics. Differences between people may operate on known diversity dimensions—for example, gender identity or race—but can also depend on mood, health, recent experiences, and personal goals. DivComp recognizes that everyone is different from everyone, moving away from a stance that one group represents the norm against which *others* are measured. DivComp will therefore require

[1] Note that we are not advocating against diversity in the workplace, or any other setting, but merely pointing out that individual differences within teams cannot fully resolve the diversity challenge.

going beyond creating shared meanings to *participating in meaning-making*, including via constructive disagreements, which are unavoidable.

Rather than focusing on the human-computer interaction, DivComp requires us to attend to the human–human interaction, as mediated by technology. On the basis of DivComp theory, we may create hardware and software to enable *participatory sense-making*, a phenomenon by which two or more people co-create meaning in interaction [8]. Thus, diversity computing devices will operate in shared—physical or digital—spaces and facilitate interpersonal interactions, online or face-to-face. DivComp draws on decades of research into the embodied and situated nature of technology-mediated practice and applies it to issues of diversity. DivComp devices will therefore be an active part of the creation of shared meaning. They will shape and be shaped by ongoing interactions of embodied agents, embedded in contextual settings. DivComp tools will be qualitatively distinct from networked individual devices, such as smartphones or activity trackers, because they'll form an integrated part of the interactive sense-making process of multiple agents as a whole, rather than providing information to individual minds as distinct units in a larger group.

In building these tools, we must acknowledge the diversity of the people coming to an interaction, invite people to participate, and make sure everyone *can* participate. Thus, self-reflection, joint reflection, and interpersonal communication will be an integrated part of the development and application of DivComp. Diversity computing should not abolish differences but instead increase the sense and meaning we can make together and gain from each other, from and with and through digitally mediated engagement. Crucially, the creation of shared meaning among diverse individuals will involve disagreements, but the presence of a DivComp device should serve to scaffold constructive discourse. DivComp devices may produce what have been called third spaces that are new to both parties in the conversation and therefore invite creative exploration of shared norms and meanings. Or DivComp devices may function as boundary objects [9] that both parties can relate to and make sense of without necessarily fully understanding one another.

Diversity Computing Methods and Machines

DivComp requires specific methodological innovations in disciplines spanning the humanities, social sciences, and life sciences, as well as those disciplines more

traditionally associated with computing innovations. In philosophy, art, and sociology, we can find ways to characterize what it is for two people to create shared knowledge and understanding. We can work with end users to understand the societal and individual impact of creating diversity computing devices and embedding these in public or shared spaces. This work should build a robust ethical foundation for defining the purpose of diversity computing and any limitations on its application.

From psychological and biological sciences, we can identify data sources that expose key elements of interactional experiences. Candidate sources include neural signals from electroencephalograms, heart-rate and skin conductance, accelerometers to detect body movements or postures, audio, and video, all gathered alongside the explicit reflections of the people involved. Methods must be developed to allow algorithms to identify instances of productive engagement—whether positive or negative in emotional content—between two people. We believe the most productive analyses will result from merging parallel data streams from two or more people and seeking out moments of convergence, co-dependence, or divergence between these samples.

Exploring interactions can be characterized as an open-ended, evolving, iterative process where both people and algorithms tentatively probe information, refine their understanding, and explore new ways to filter, engage, and make use of various data sources (see “DivComp and Gender” sidebar). To escape the pervasive influence of sociocultural norms, diversity computing algorithms should mimic how people learn new self-taught information. When we teach ourselves a skill, we are constantly transforming our knowledge about the context. Creating such explorative and dynamic machine-learning algorithms to work in the same way will be a grand challenge for machine learning and social signal processing.

Sidebar 2: DivComp and Gender

While relations between men and women operate successfully at an interpersonal level much of the time, established power structures in most societies reinforce masculine advantages and operate to exclude or undermine women. The assumption here is that such power structures are reinforced at the level of nonverbal, situated practices rather than at the rational, conscious level of intent. DivComp devices in workplace meeting rooms would target these social dynamics, for example by recording speaker time as

well as behavioral and physiological responses (e.g., fidgeting, shuffling, overall posture, heart rate and skin conductance) that are candidate markers for psychological states such as domination, attentiveness, and anxiety. The markers could then be mapped onto various situated forms of interactive feedback; for example, a dynamic change of lighting, ambient sound, or haptic feedback in clothing. Participants in the meeting are afforded subtle cues that help them to interpret the "social condition" of the conversation and other individuals. In this way, DivComp devices become extended social senses that allow people to read situations on the basis of conversational features they might otherwise miss. Such additional senses would influence the social dynamics of a group while at the same time inviting a reflective practice for more equal or fair participation.

DivComp users may not have a specific goal but merely seek information to help understand what is going on in the current social encounter. They will not, at first, know what aspect of the available data they are interested in: It could be the automated detection of emotional states, whether they have matched heart-rate rhythms, how long each person has been speaking, or whether they are synchronizing their gestures. The most valuable content might also result from a combination of different data streams, perhaps weighted to increase the influence of the most useful sources, or organized into a certain temporal order. Users can take an opportunistic approach, changing and re-specifying their objectives or their strategies of exploration. Every round of activity would lead to different information-seeking activities, changing both the users and the device. Thus, the exploration process builds a mutual understanding between system and users; that is, how users understand the information provided by the system and how the system understands the users, and how all parties make use of information to understand each other. This mutual understanding formation is not a one-off process, but rather an iterative loop.

Applications of Diversity Computing

What are the applications of such technologies, if they can be built? We envisage a future where DivComp devices are integrated technologies, operating in corporate, political, leisure, and mundane personal spheres. They will be available in boardrooms and political debate chambers, at negotiation tables, in doctors' offices, and in those of school administrators. There, they will invite and support embodied participatory sense-making. Concrete results from the introduction of diversity computing might include more

effective application of equal hiring practices, smoother international cooperation and negotiations, and improvements in the management of family disputes.

One specific potential contribution of diversity computing would be toward the neurodiversity agenda (see “DivComp and Neurodiversity” sidebar). This sociopolitical movement emphasizes diversity in brain structure and function, giving rise to what are known as neurodevelopmental disorders or mental health conditions such as attention deficit hyperactivity disorder, schizophrenia, Tourette’s syndrome, or autism. Most existing assistive technologies created for use by neurodivergent individuals are designed from a “fixing things” perspective; that is, to regulate behaviors of people and train them to understand and follow the same social norms as everyone else. Adopting a fundamental moral and ethical position of acceptance of difference [10], diversity computing would enhance inclusion, facilitate mutual understanding, and enable individuals to find their own way in social situations.

Sidebar 3: DivComp and Neurodiversity

Repetitive physical actions, or “stimming,” are increasingly recognized as a positive coping mechanism for autistic people. A future DivComp device might help non-autistic persons to relate to such movements and appreciate their benefits and motivations, rather than judging the behavior against the social norm. A DivComp device would provide real-time feedback for the non-autistic conversation partner about the level of arousal or anxiety, and the regulatory effects of stimming behaviors. Equally, the autistic person would receive feedback on how confusing or uncomfortable their behaviors are for their conversational peer. Both parties could use this information to regulate aspects of their interaction, reflecting on individual needs (e.g., coming to rest, feeling comfortable) and building a shared meaning as conversational partners. The mapping of feedback could be shared via a visual display, soundscape, or haptic feedback in an interactive object that can be held. This would facilitate sharing meaning-making by providing information to both conversation partners and challenging the normative judgment of such activity as objectively negative or unwanted.

Essentials of DivComp

At the outset of this article, we proposed that DivComp required a combination of philosophical and cognitive theory, participatory methodology, and digital innovation. The

theoretical basis we propose is that people co-create meanings by participating in each other's sense-making activities. Fluent, fruitful, and respectful sense-making is impeded by human cognitive biases—stereotypes, prejudice—and lack of shared knowledge. Modern social networks tend to exacerbate these biases, where we should focus more on challenging and undermining them. Creating devices to do so requires participatory methods: self-reflection and reflecting with each other will be a core part of both the creation and implementation of DivComp. Digital innovation is required at the level of the sensing and processing of appropriate data, but also in the ways in which these are represented and interacted with. The ideals of DivComp rest equally on all three components—theory, methodology, and technology.

The Way Forward

No doubt, we are a long way from building a true diversity computing device as set out here, let alone from achieving the goals of diversity computing. The multidisciplinary challenges ahead are significant and include building algorithms that operate without recourse to normative benchmarks, shaping ethical guidelines for integrating diversity computing devices into shared spaces, and supporting adequate user involvement to permit iterative usage cycles to cross a threshold of usefulness. Of these, one key element not explored in detail here is the need for DivComp to be associated with responsible, transparent, and accessible procedures to enable user consent and opt-out.

Nonetheless, we hope this article has articulated a vision for the role computing might play, not just in recording or facilitating interactions, but in *shaping* and *developing* shared meaning between people. We envisage a future where diversity computing devices will support fluency, respect, and egalitarianism in interpersonal interactions in contexts ranging from political negotiations and international trade deals to corporate hiring panels and romantic encounters. Anywhere that individual differences impede mutual understanding and effective working, diversity computing will have a role.

Endnotes

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