Representing Systems of Human Need and Satisfaction

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ABSTRACT

The sustainable development and ecological economics communities have called for research into representing *sustainable consumption corridors*, which are intended to represent ways of living at both the upper and lower bounds of sustainability. This research draws on psychological and philosophical theories of human need to motivate a network data structure for capturing the sustainability of an individual's lifestyle. We present a muiltilayer intra-individual network model and corresponding network visualization prototype, to represent the ways that individuals experience need and satisfaction (collectively, their *need satisfaction system*). Attributes about needs, satisfiers, and the relationships between the two are encoded in various channels of the network visualization, enabling rich representations of one's need landscape. This visualization builds toward operationalizing sustainable consumption corridors and providing an alternative to lossy and misleading aggregate measures of human progress.

1 INTRODUCTION AND RELATED WORK

The escalating environmental crisis motivates research exploring ways for humanity to live indefinitely within planetary boundaries. A common goal espoused in the sustainable development community is to promote "development that meets the needs of the present without compromising the ability of future generations to meet their own needs" [24]. From this goal arose the concept of *sustainable consumption corridors*, which explicitly affirms the existence of a lower bound of consumption that is necessary to meet basic needs, and an upper bound of consumption that exceeds planetary limits [10]. The challenge, by extension, becomes one of evolving social systems such that the consumption patterns of all humans fit within these corridors.

One of the key challenges in operationalizing the concept of sustainable consumption corridors is in the "potential strategies for the design" and the "definition and implementation of such corridors" [5]. Indeed, actualizing sustainable consumption corridors will require no less than specific, quantifiable representations of one's everyday life and the impact it has (collectively) on the environment. This should be a call to arms for the information visualization community: to design visualizations that serve as useful tools for thinking about sustainable consumption corridors at various scales of social organization (the individual, the group, the society, etc.).

In this paper, we detail this call to arms, and describe both a network data model and a corresponding prototype visualization tool that express representations of an individual's lifestyle—or, more specifically, their system of need satisfaction (a *need landscape*). We begin by providing a brief overview of sustainable consumption corridors, and discuss various conceptualizations of human need that may be used to scaffold their design and understanding. Based on a conceptualization of human need satisfaction as a complex system, we have developed an intra-individual network model for representing human need and satisfaction, and we present a prototype network visualization tool for exploring these models[1]. We close with a discussion of various ways the information visualization community might support efforts to operationalize sustainable consumption corridors and ensure humanity's long term well-being.

1.1 An Alternative to Lossy, Aggregate, and Poorly-Aimed Progress Indicators

The drawbacks of measuring human progress with raw consumption levels (such as gross domestic product (GDP)) have led to an increase in human consumption, without a necessarily equal rise in human satisfaction (see the (1974) Easterlin Paradox [8] and the most recent (2021) empirical study [30]). These authors argued that the GDP fails to capture the human condition, and that we should use different indicators to judge the progress of nations. As a result, a variety of new numbers were proposed that include more direct measures of human well-being.

Measures such as gross national happiness (GNH) and the human development index (HDI) capture more diverse aspects of the human condition, but are effectively flawed due to the same issues that compromise GDP-based measures: namely, these measures are subject to arbitrary judgements from various decision makers and ignore localized social system dynamics [30]. In addition, aggregating ways of living into a single number requires quantitative trade-offs between satisfaction of various needs [4] and can lead to unintended consequences [26]. For example, in 2010, the HDI started to value its three components (longevity, schooling, and income) using a geometric mean, which rely on arbitrary lower bounds and led to a devaluation of longevity (especially for developing countries) and a potential overvaluation of years of schooling [27]. If development efforts blindly seek increases in HDI, then this change may lead to sacrificing years of life of individuals in developed nations for additional years of schooling, a tradeoff that should not be made without explicit participation of those affected.

Regardless of intent, these aggregate measures of human development are lossy and often misleading. A culture built around optimizing for GDP has not resulted in the 15-hour work week predicted by Keynes [15] but instead has produced a widespread hedonic treadmill of low marginal utility [14], ensuring ever-increasing detriment to the environment without which the treadmill cannot run. The relationship between consumption and satisfaction is improperly coupled—consumptive activities do not effectively or equitably provide satisfaction across all needs nor across all humans. Not only are individuals living without meeting their basic needs in the present day, the ability for future generations to meet their needs relies more and more on fragile, human-created systems, as opposed to the complex and evolved natural systems that have instead been sacrificed for use as building blocks of the former. For example, compare the robustness of a natural forest to that of a plot of industrial farmland, or even a managed monoculture forest [29].

While the stated objective of the World Commission provides motivation enough for studying human need and satisfaction, the

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[1] Available online at michaelhoefer.com/files/index.html, although not all of the proposed features described in the paper have been implemented in the graphical interface of the tool.

still-needs-to-be-actualized concept of sustainable consumption corridors further motivates the development of a structured way of representing everyday life and its various satisfying activities. The idea of sustainable consumption corridors is that there are bounds to sustainable consumption. One side of the corridor borders on deprivation and the other on excessive consumption, exceeding planetary limits. Lifestyles in the middle of the corridor represent lifestyles that are acceptable, as long as everyone stays within the corridor. These consumption corridors effectively tie together notions of individual consumption (satisfying the needs of today) and sustainable development (ensuring those of the future can satisfy their needs) [5] and are not necessarily biased towards any particular scale of intervention (e.g., supporting interventions ranging from individual behavior change to large-scale cultural change).

We therefore propose moving away from single aggregate metrics (GDP, HDI, etc.) and instead towards new representations of the lives of the individuals in the social system in question. Living within consumption corridors becomes the new goal: **ensure everyone's basic needs are satisfied and that collective consumption is sustainable at scale**.

The potential benefit of sustainable consumption corridors will only come with operationalizing the concept [10], which will require filling many knowledge gaps. In this paper, we propose the idea of using networks to represent this complex system of need and satisfaction, and pull on network visualization strategies to aid in reasoning about these systems.

1.2 The Need for Consensus on Universal Basic Needs

One of the (many) unstated preconditions for actualizing sustainable consumption corridors is an agreed-upon method for evaluating if an individual's needs are being met. Without knowing this, one cannot determine the minimum levels of consumption (satisfying activities) necessary for an individual to be basically satisfied. We interpret the idea of "designing" consumption corridors [10] not as if they could (or should) be crafted from scratch, but rather proposing designing a *representation strategy* of the corridor itself, which is composed of lifestyles on the border of deprivation and excessive consumption. Rather than designing anew, existing lifestyles can be made more prominent and available for copycat-style adaptations. There are plenty of both deprived and excessively-consuming individuals for the rest of us to learn from, not to mention those who are currently living lives that would fit within a sustainable consumption corridor. Analyzing the currently-lived lifestyles (in diverse cultures across earth), with respect to need and satisfaction will likely uncover effective sustainable ways of living "the good life" [25] across varying levels of income.

To design a representation of need and satisfaction, we turn to ideas from psychology, development economics, and philosophy. The scientific literature on human need is broad, scattered, and in disagreement. While scholars such as Sen [31] and Nussbaum [23] advocate for a capabilities approach, a human needs-based approach more easily lends itself to operationalization and may, in fact, accommodate the capabilities approach [5]. As Dean put it, "[Despite its importance] need is also a concept that is interpreted in a mind-boggling variety of ways" [4]. A review of theories of need is beyond the scope of this paper (see [4] for exactly this), but we will share key related findings.

There is no apparent consensus as to the constituents of a universal set of basic needs. Doyal and Gough suggest there are two basic needs (physical health and autonomy) [7], while Max-Neef proposed a matrix of nine needs [19]. Max-Neef, and even Maslow in his original 1943 paper [18] both disclaimed that they did not know the basic set of needs, and they provided a list merely as one possible demonstration of their theories. If nothing else, most recent work agrees that measurement should be participatory and involve those being measured to help discover what the universal set of basic needs might be (or even if it exists). In line with this notion is the strategy of conducting large scale empirical studies (enabled by the right representation(s) of need and satisfaction) to provide insights towards reaching a consensus on the basic set of needs (or lack thereof).

We suggest that one of the reasons for the lack of consensus is the lack of empirical data on need satisfaction. It is possible that humanity has gotten to this point without developing an effective system for thinking about human need. In fact, nonviolent communication advocates (specifically, Marshall Rosenberg) suggest that part of the reason we are not getting our needs satisfied is that we do not espouse and communicate them to others [28]. While Rosenberg's work focuses on interactions between individuals, the same idea can be expanded to higher levels of social organization. If individuals have no way to effectively communicate information about their individual systems of need and satisfaction to policy makers (or others seeking to evolve social systems), it is challenging to make decisions that will systematically improve satisfaction in a population. The tools for improving this current deficit in representing and communicating need may include new ways of structuring data about needs (like the one suggested in section 2) and new ways of visualizing such structures (shown in the prototype).

1.3 Need and Satisfaction as a Complex System

Ecological economists, in part, seek to understand how environmental services support the satisfaction of human needs. Dodds suggests a high level of analysis is necessary—one that includes the dynamics of interacting social, economic, and environmental systems [6]. In addition, Max-Neef provides an imperative that we "understand human need as a complex system" suggesting a potentially effective level analysis for sustainable development activities. Sustainable consumption corridors are one way of understanding individually experienced need (social systems) alongside collective planetary boundaries (environmental systems), mediated by the relationship between the two (economic systems).

The study of complex systems often utilizes a network data structure to represent pieces of, and relationships between, parts of the complex system [22]. In the following section, we combine ideas from ego networks, which are centered around individuals and their social ties [2], and multilayer networks, which consist of multiple "aspects" (effectively "dimensions") and associated network layers [20], to construct a multilayer network model of an individual's need and satisfaction, underlying an interactive visualization tool.

There have been other efforts that seek to represent and visualize lifestyles and their collective environmental impacts, ranging from small scales (such as studying sustainability of school meals [11] or individual household energy use [33]) up to the large (for example, intergenerational development of public *bads*—as opposed to public *goods*—in Japan [1]). A recent publication provided a visualization plotting the number of biophysical boundaries transgressed with the number of social thresholds achieved, as well as a radial bar chart showing aggregate measures of social development and environmental impact [25]. Related to these efforts are those that advance the field of designing personal informatics systems [9, 17], and the related area of personal and visual analytics [13], which both seek to improve understanding of the self through "data-selfie" visualizations [16]. The task of representing and visualizing one's systems of need and satisfaction can, indeed, be approached from the perspective of personal analytics.

2 A Network Visualization of Systems of Need and Satisfaction

An important conceptual advancement is Max-Neef's suggestion of explicitly separating *needs* and what he coined *satisfiers* of those needs: the ways in which needs are satisfied [19]. In Max-Neef's formulation, basic needs are the same for everyone across time and

universal across cultures ("finite, few, and classifiable" [19]). What varies from person to person (often mediated by culture or constructed sociotechnical systems) are culturally influenced satisfiers. In other words, according to Max-Neef, people all have the same fundamental basic needs, but the way in which they meet those needs (via satisfiers) differs.

Our proposed network model draws on these concepts. An individual node in the network represents either a need or a satisfier. The relationships between satisfiers, and the needs they satisfy (or fail to satisfy), are represented as edges between the two nodes. If a satisfier is used to satisfy a given need, then an edge is constructed between the satisfier and the need it satisfies. A bipartite network is then constructed as the entire set of need nodes, satisfier nodes, and relationship edges between each pair. As need is experienced by diverse individuals with diverse systems of need satisfaction, each individual will have a different *need network*, a type of intra-individual ego network [12]. A sample need network is shown in Figure 1.

The data supporting this visualization could be generated by (at least) three possible data collection processes:

- Through a survey that facilitates systematic reflection, yielding subjective reports of levels of need and satisfaction, and assignment of satisfiers to needs (perhaps pre-selected from one or more of the various theories of human need mentioned earlier)
- By labeling and aggregating data on more objective measures of human lifestyles, such financial transactions or calendar entries
- By constructing and pulling from databases containing estimates of various environmental effects of certain satisfying activities (including amortized collective impacts).

A detailed discussion of these approaches is beyond the scope of this paper, thus we move onto a discussion of how need and satisfier metadata can be encoded in the visual channels of a network visualization.

2.1 Encoding Need–Satisfier Relationship Metadata in Edges

Various display parameters of the edge arrows can encode a host of different characteristics of satisfier–need relationships. The width of each link in Figure 1 indicates the extent to which a particular satisfier is used to meet the connected need. For any given epoch of time, the edge weight can be calculated as the reduction in area under the curve of a graph plotting experienced need over time[2]. Figure 1 shows an individual who gains more satisfaction for the need of physical connection from food as opposed to alcohol. The colors of the links encode the user's *meta-satisfaction*: the extent to which they are satisfied with the particular need–satisfier relationship. Gray-blue edges imply that the user feels good about using a particular satisfier to meet a particular need, while red links indicate that the user would like to change a particular need–satisfier relationship. Green links imply that the individual would like to have/experience this need–satisfier relationship in the future, but currently do/does not. Dashed lines indicate that the individual feels this particular need–satisfier relationship is unobtainable at the current moment. The meta-satisfaction color encoding helps create a rich visual representation of an individual's lifestyle, with clear indication of areas where they may want to focus on behavior change.

[2]The time-dependence of the experience of need and satisfaction suggests a temporal network model may provide a more fine-grained representation of systems of need. For our purposes here, we can think of the networks as representing a time slice of a larger temporal and dynamic network.

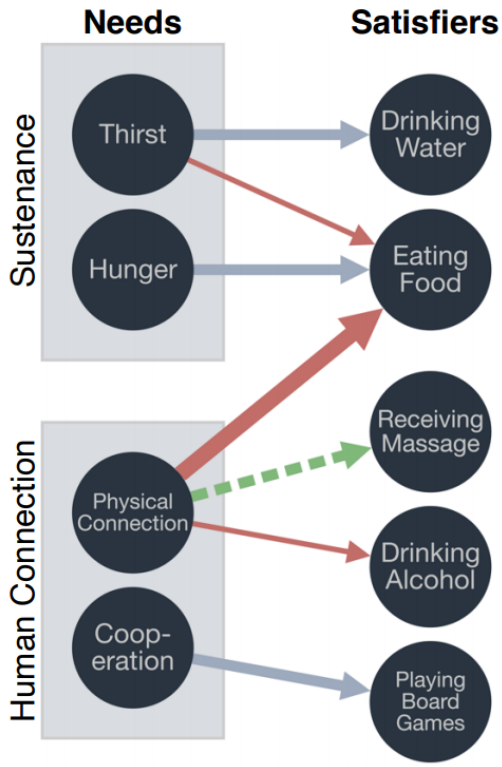

Figure 1: Network Visualization of Human Need and Satisfaction

2.2 Encoding Need and Satisfier Metadata in Nodes

The environmental impact of an individual's need satisfaction system can be uncovered by looking at the satisfiers, and encoding environmental cost in the visualization. For example, the nodes could be sized (or colored) according to the pounds of CO_2 that a certain activity produces (or another impact with an associated planetary boundary, such as those used in [25]). This approach would provide individuals with a clear representation of the impact that certain aspects of their lifestyle have on the environment, and can help identify where satisfying activities exceed sustainable limits. Alternatively, financial cost or length of time spent could be encoded in node size, painting a clear picture of the economic and temporal burden of meeting each need. Lastly, the frequency with which a given satisfier is used to meet a need may be another relevant piece of metadata incorporated into these visualizations.

Nodes representing needs can be sized based on the extent to which a particular need is satisfied. For example, needs with low levels of satisfaction can be sized larger, to indicate a bigger unmet need in the life of the individual. This approach may also motivate behavior change, enabling exploration of the effects of adding or removing satisfiers that contribute towards meeting the particular unmet needs. The prototype visualization system currently supports changing colors and text on the fly, but requires direct modification of the underlying JSON object (accessible via file exporting and re-uploading) to resize edges or nodes.

2.3 Network Motifs Represent Different Types of Satisfiers

Max-Neef suggested a series of types of satisfiers in [19], which can be visually identified via a series of network motifs and indicators. **Singular Satisfiers** are satisfiers that provide satisfaction for only one need, as opposed to **synergistic satisfiers** which satisfy more

than one need [19]. The number of needs satisfied by a satisfier can be determined via the satisfier's degree (number of connected edges), a common measure of ranking nodes in network analysis [22]. This ranking could be used to identify the most effective satisfiers in an individual's need-satisfaction system. Figure 2 shows both a singular satisfier (with only one connected need) and a synergistic satisfier (with multiple needs being satisfied by the same satisfier). In the example, "watching television" is a relatively less satisfying activity for leisure as compared to "dinner with friends" (as indicated by edge weight), but happens with greater frequency (encoded in satisfier node size). The individual currently experiences a greater need for belonging and leisure than for hunger (encoded in need node size).

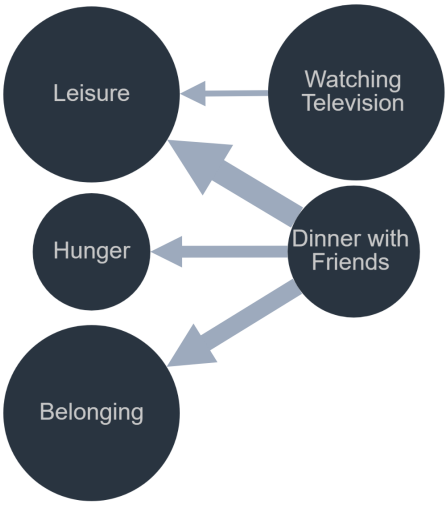

Figure 2: A partial network with two visible motifs - a singular satisfier (television) with a degree of one, and a synergistic satisfier (dinner with friends) with a degree of three.

Pseudo satisfiers are those that only appear to satisfy a given need on the surface, but leave the underlying need unfulfilled [19]. We would expect this satisfier could be identified by a large satisfier node size (if encoded with frequency or time, for example), alongside a small edge weight leading to its associated needs (if encoded to represent the amount of satisfaction a particular satisfier provides the particular need). In fact, the singular satisfier in Figure 2 (watching television) may very well be an example of a pseudo satisfier, given its depiction of a high frequency and low satisfaction.

Inhibiting satisfiers oversatisfy a given need at the expense of other needs [19]. This implies that a need can be satisfied more than is necessary. Edges representing inhibiting satisfier relationships might be shown by creating a dual-colored edge. One color represents the amount of "necessary satisfaction" a satisfier provides, while the other represents the amount of "over-satisfaction." As inhibiting satisfiers can also *increase* experiences of other needs, a third edge color could be used to indicate a reduction in satisfaction. The current visualization can simulate this effect by using multiple edges to represent each of normal-satisfaction, over-satisfaction, and reduction in satisfaction.

2.4 Aggregation and Multilayer Network Visualization

Collections of individual need networks can be grouped together into a multilayer network, with each layer representing a single individual in the group. The universality of the basic set of human needs (if yet undiscovered) suggests that many, if not all, need nodes will be consistently shared across many of these layers. This characteristic may enable the construction of useful group-level networks, representing the needs and satisfaction of groups of people at arbitrary scales of social organization. By collapsing the individually-generated layers by aggregating edge weights, for example, one may be able to create a visualization that is able to improve the legibility of larger-scale systems of need and satisfaction. For example, such a representation may improve the understanding of the roles that various organizations play with regards to collective need satisfaction. The model supports arbitrary scales of organization. Networks representing need satisfaction systems of entire countries, corporations, religious organizations, households, or even two individuals in a relationship (a dyad) can be created by combining all the layers corresponding to individuals in the social system of interest. The relatively new research area of multilayer network visualization [20] is expected to assist in visualizing these larger systems of need and satisfaction.

3 Future Directions for Visualization

The network model and visualization presented in this paper is but a first attempt at representing the system supporting an individual's (or group's) needs and satisfaction. While the model provides a framework for structuring new data about need satisfaction systems, the generation of the underlying data remains an open challenge.

To support the three suggested routes of data elicitation, personal informatics researchers can develop systems that facilitate both systematic reflection to generate subjective data directly about need satisfaction systems, as well as provide interactive systems for engaging with objective personal data (financial transactions, calendar entries, etc) for the purpose of constructing visual representations of one's need landscape. In addition, personal and visual analytics researchers can empirically assess the ways in which individuals make sense of and utilize these personal visualizations once they are constructed [32]. Information visualization researchers are also well-suited to continue working improving the effectiveness of these visualizations for reflection [3] and empathy [21].

Increased attention on designing, implementing, and evaluating systems of need and satisfaction stands to improve need literacy in the population, enabling individuals to better elicit representations of their specific need landscape. Once this occurs (perhaps using tools like these, generated by the information visualization community), further effort will be required to visualize the aggregated multilayer networks, representing larger social systems, in a way that is useful for decision- and policy-makers. The important goal of this proposed approach is to create representations of human lifestyles that are scalable and useful at different levels of organization and that serve to measure human progress and guide productive activities better than single aggregate measures that have failed to deliver systems of need satisfaction that meet the basic needs of all.

4 Conclusion

In this paper, we sought to provide a narrative of the attempts at measuring the progress of social systems, and suggest that a one-layer-per-individual network representation of human need and satisfaction may serve as a useful tool for system change at the level of the individual ranging up to the level of the nation or planet. An effective visualization of systems of need satisfaction unlocks the ability to represent an individual within a sustainable consumption corridor. Aggregating individuals into multilayer networks, and visualizations based on collapsed edges, can enable representation of need satisfaction at arbitrary scales of social organization.

We discussed the role that information visualization researchers might play in operationalizing sustainable consumption corridors, and we presented a model and corresponding prototype visualization that can serve as a jumping-off point for future work that supports sustainable development. This paper hopefully reinforces the important role of information visualization in the pursuit of a world where "the good life" is possible for all those alive both now and in the future.

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