Developing Computational Models of Players' Identities and Values from Videogame Avatars

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ABSTRACT

Videogame avatars, while technically virtual identities, also often reflect the aspects of players' identities and values in the physical, social, and cultural world of the player outside of the game (i.e., the "real world"). These aspects of real world identity include phenomena such as social group categorization and stereotyping. In this paper, we present *AIRvatar*, an Artificial Intelligence (AI) system that models player values and social identity related phenomena from the computational data structures of virtual avatars. We conducted a user-study with 191 participants who created characters using an avatar creation system of our own design together with *AIRvatar*. We then constructed identity models of players by analyzing the graphical images, text descriptions, and numerical attribute distributions of these constructed avatars. These allowed us to identify and characterize aspects of players' real-world values related to identity (e.g., gender-based stereotyping and stereotypical associations of traditional videogame roles,) from the technical data structures and implementations of players' avatars.

Categories and Subject Descriptors

K.8.0 [**General**]: Games.; K.4.2 [**Social Issues**]

Keywords

Non-Negative Matrix Factorization; Avatars; Identity

1. INTRODUCTION

Many videogames provide avatar or character constructors that allow players to select and customize their virtual identity representations. The formation of identity in relation to players and these virtual representations can be characterized by Zach Waggoner's discussion of *avatars*. Rather than just focusing on the technical implementation of avatars, Waggoner calls attention to the "liminal space between the user and the videogame avatar, between the materiality of the player and the imagination" [20]. Indeed, in videogames avatars are often associated with a player's virtual representation through *characters*, which are more than just proxies for the player, but are imaginatively embedded in the narratives of videogames through various means such as numerical attributes, behavioral characteristics, and backstories.

In this paper, we present *AIRvatar*, an Artificial Intelligence (AI) system that collects game telemetry data for avatar[1] creation systems and analyzes them to create computational models of players and their behaviors. We used *AIRvatar* in a user-study with 191 participants, where they created and customized the visual, textual, and numerical features of avatars using an avatar customization system of our own design, set in the context of a fantasy computer role-playing game (RPG). We demonstrate how social phenomena such as gender-based stereotyping can be revealed through numerical attribute statistics and how the values and preferences held by players toward their videogame avatars can be identified and modeled using a technique called non-negative matrix factorization (NMF). We revealed how words used by players to describe avatars could be implicitly categorized according to common archetypal RPG roles and the types of stories being told by players. We also used NMF to perform a graphical analysis of created avatar images, revealing underlying patterns in them and demonstrating how the values of players related to how and why they choose to customize their avatars. Our findings highlight the importance of considering the underlying implementations used to construct avatar representations. If developed without due consideration, such representations may result in inadvertently perpetuating undesirable social implications related to identity such as marginalization and stereotyping [7].

2. THEORETICAL FRAMEWORK

Our work here builds upon a foundation at the intersection of research on digital media studies, cognitive science, and artificial intelligence. We briefly summarize insights from these areas and describe how they relate to our endeavors.

2.1 Avatars as Blended Identities

Previous research has demonstrated that the way players behave in both the real and virtual worlds can be influenced by these virtual avatars [10, 22]. These virtual avatars and behaviors may reveal aspects of a player's real-world identity such as their demographic profiles, personality traits,

[1]While acknowledging the distinctions laid out above, we shall use term *avatar* going forward in this paper.

Proceedings of the 10th International Conference on the Foundations of Digital Games (FDG 2015), June 22-25, 2015, Pacific Grove, CA, USA.
ISBN 978-0-9913982-4-9.

and motivations for play [21, 23]. Furthermore, they may also reveal phenomena that reflect real-world social constructs, such as conforming to notions of ideal body types or gender-related stereotypes [4, 10, 15, 16]. Such socially disempowering phenomena in virtual environments can have deep social implications [7], such as peoples' performances being impacted by stereotypes [18]. To describe the interrelationship between virtual and real-world identities, we begin with James Gee's definition of third type of identity, which he terms the "projective identity" [5]. It is a manifestation of values associated with both the player and avatar. We extend upon this notion using Harrell's concept of a "blended identity" [9]. Here, aspects of a player's real-world identity (e.g., preferences, control, appearance, understanding of social categories, etc.) are selectively projected onto the actual implemented avatars, represented through the computational data structures used to create them. We hypothesize that studying these underlying data structures can consequentially be used to reveal aspects of a player's real-world identity. The following taxonomy of shared technical underpinnings of computational identity applications by Harrell [7] is used to formalize these technical implementation components for modeling social constructs and identity-related phenomena [5]. They are: 1) static media assets, 2) flat text profiles, 3) modular graphical models, 4) statistical/numerical representations, 5) formal annotation, and 6) procedural and behavioral rules. They provide a basis for the construction of avatars, which are highly expressive in both visual appearance and behaviors.

2.2 Cognitive Models of Categorization

We briefly describe several cognitive categorization models useful to define social relationships, preferences, metaphors, and values. Leveraging such models can help us computationally model aspects of identity such as highly dynamic and nuanced social identity-related phenomena [8]. Recent theories are based on identifying members that are deemed "better examples" of a category than others, which are termed *prototypes* by psychologist Eleanor Rosch [17]. Thus, categorization of individuals can occur based on their perceived distances relative to these prototypes. Cognitive scientist George Lakoff extends upon these models with what he terms "prototype effects," based on the theory that categorization is an cognitively-grounded and imaginative process involving metaphorical projection [13]. Useful definitions for this paper are *stereotypes* (commonly held, but often misleading, category expectations) and *ideals* (culturally valued categories, which may not be typically encountered.) These definitions provide us with a formalization to describe and reason about the cognitively grounded categorization models, termed idealized cognitive models [13], used to algorithmically represent social identity related phenomena.

2.3 Non-Negative Matrix Factorization

Non-negative matrix factorization (NMF) is an algorithmic process for representing data as a combination of derived factors. As an example, given a data set of face images, NMF can be used to learn the "parts" that make up the images of faces (e.g., eyes, nose, mouth) [14]. The major difference between NMF and other similar dimensionality reduction or data vectorization techniques such as Principal Component Analysis [12] is the non-negativity constraints imposed on the factors, which allows easier qualitative interpretations of their representations. NMF produces a smaller number k of interpretable base factors that represent the original data set. Formally, given a data set of points $V = \{x_1, x_2, ..., x_n\}$, NMF decomposes the matrix $V \in \mathbb{R}_{n\times m}$ into an approximation $\hat{V}$ that is the product of two matrices $W \in \mathbb{R}_{n\times k}$ and $H \in \mathbb{R}_{k\times m}$, with elements $v_{ij} \in V$, $w_{ij} \in W$, and $h_{ij} \in H$ all ≥ 0. The value of k specifies the number of sub components desired and $k << n, m$. NMF seeks to minimize the difference $||V - \hat{V}||_F^2$, where $||X||_F^2 = \sqrt{\sum_{i=1}^{n}\sum_{j=1}^{m}|x_{ij}|^2}$ is the Frobenius norm of the matrix X. Each row in matrix H is a m-dimension *basis vector*, or base factor, and each column in matrix W relates each sample in v_i with each base factor through *coefficients* $w_{ij} \in W$, describing the strength of the representation of each base factor j in sample x_i.

3. USER STUDY

We conducted a user study with participants from the social news and discussion site *Reddit*. A post was made on the `/r/samplesize` sub-reddit inviting users to take part in a user-study where they would be creating avatars for a videogame setting. Each participant had to sign a consent form, which was approved by the human subjects research committee at our institution. Participants were informed that it was a research project and that analytical data would be anonymously collected during the customization process. Participants then created characters using an avatar customization system (described in the next section) that we made[2]. After creating their characters, participants completed a demographic survey. 104 participants (54%) identified as "Male", 81 (43%) identified as "Female", and 6 (3%) listed "Other." This gave a fairly representative distribution between genders. For age-groups, 154 participants (80%) were between "18-24" years old, 32 (17%) were between "25-34" years old, and the other age groups were $< 1\%$. Players spent 10 minutes on average customizing their avatars. This allowed us to study the identities and values of everyday users and their attitudes without requiring familiarity with videogames or particular genres of videogames.

4. METHODS

We created an avatar customization system with *AIRvatar* as its backend. Prior to customizing their characters, players were presented with an introductory videogame opening scenario featuring a familiar fantasy setting of a computer role-playing game where the player would be the main protagonist. This was to contextualize the style of the assets and motivate players to create characters as they would for a videogame and not just a stand-alone avatar creator. We next discuss the different technical components of the avatar creation system made available to the player.

Static Media Assets - Images. Players had two choices of avatar genders[3] to select from. Next, players were provided gender-specific base image and assets across the five customization categories (hair, head, body, arms, and legs) to customize the visual appearance of their characters. In

[2]Art assets were from the publicly available *Mack "Looseleaf" Avatar Creator* [2] and *Liberated Pixel Cup* [1]

[3]We follow role-playing conventions here, but recognize the distinction between gender and sex. In future work, we seek representations that decouple biological sex and gender.

each category, several sub categories of assets gave players more fine-grained control over their avatar's appearance, e.g., gloves for hands or pads for shoulders under the arm category. Players were provided an animated preview of their avatars and could rotate the view in any of the four directions, but analyzed using its 32×48 front-facing image.

Text Profiles – Tags and Descriptions. Players were provided with two ways provide text-based representations for their created avatars. First, players were asked to provide simple one-word *tags* for their avatars (e.g., "strong, clever, brooding"). Secondly, players were provided input for *free-text entry*, enabling them to provide more verbose descriptions of their avatars. Both inputs were optional and each had an example help text as a guide for players.

Numerical Attributes – RPG Stats. Players allocated statistical attributes values of six commonly used computer role-playing game attributes. They were chosen due to the fantasy context of our avatar customization system and introductory sequence. These attributes, with a brief descriptions in parentheses, were: Strength (to deal damage), Endurance (to sustain damage), Dexterity (to perform moves quickly and accurately), Intelligence (to level up quicker), Charisma (to charm, convince, or converse well), and Wisdom (to cast spells and magic). Each attribute was given a default value of 4 points on a 7-point likert scale, with 3 points left unallocated, for a total of 27 allocatable points.

4.1 Model Construction with NMF

Given a player i and component j, each player is represented as a feature vector v_{ij}. A data set of all $N = 191$ players for a particular component j would be represented as a $N \times M$ matrix V_j for performing non-negative matrix factorization. The feature vector v_{image} was created by flattening the 32×48 avatar image. Since each pixel is represented by RGBA values, the number of features $M = 32 \times 48 \times 4 = 6144$. The feature vector $v_{attributes}$ has $M = 6$ to correspond to the six types of customizable attributes. Both v_{tags} and $v_{description}$ were constructed using bag-of-words (BOW) representation. For tags, the number of features M corresponds with the number of unique tags observed across the data set. For descriptions, the number of features M, corresponding with the total number of unique English word terms observed after tokenizing each of the text descriptions in the data set.

5. RESULTS & FINDINGS

We present results and findings from analyzing the data collected from our user study using non-negative matrix factorization. From our analysis, we found that $2 \leq k \leq 4$ basis vectors provided sufficient results for discussion.

5.1 Revealing Stereotypes with Attributes Stats

Results from NMF on data set $V_{attributes}$ are shown in Table 1 above. We observed that players *appeared to associate certain attributes according to the conventions of "Physical-Fighter" versus "Wise-Mage" roles.* For example, strength and endurance attributes consistently contribute highly to the same factor, while intelligence, charisma, and wisdom appear do so for another. We also observed that *players also negatively associated certain attributes with each other, a behavior that reflects possible stereotypical influences from real world knowledge or past experiences.* For example, strength is consistently distant from wisdom. This corresponds to our

k	fac.	attributes *(in order of decreasing weights)*
2	1.	strength endurance dexterity charisma wisdom
	2.	wisdom charisma intelligence endurance strength
3	1.	strength endurance dexterity charisma wisdom
	2.	wisdom intelligence dexterity endurance strength
	3.	charisma intelligence dexterity endurance strength
4	1.	strength endurance dexterity charisma wisdom
	2.	wisdom endurance intelligence dexterity strength
	3.	charisma intelligence endurance wisdom dexterity
	4.	intelligence dexterity wisdom charisma endurance

Table 1: Base factors obtained from non-negative matrix factorization on attribute statistics.

previous findings in [16] that female players created more gender stereotyped characters such as male characters with high strength and endurance, but low intelligence and wisdom, compared to females. NMF thus models implicit associations that reflect stereotypical notions of players, which appear externally constructed and not system-specific.

5.2 Discovering Roles and Categories with Tags

k	factor	tags *(Top-5 by coefficient weights)*
2	1.	clever intelligent quick agile smart
	2.	strong tough intelligent powerful fighter
3	1.	strong tough intelligent powerful fighter
	2.	clever intelligent agile quick wise
	3.	smart charismatic kind cunning
4	1.	clever agile wise quick independent
	2.	strong tough powerful fighter tanky
	3.	intelligent agile quick quiet fast
	4.	smart charismatic kind cunning

Table 2: Base factors obtained from non-negative matrix factorization on textual tags.

Results from NMF on data set V_{tags} are shown in Table 2 above. Each basis vector forms a "topic" for interpretation through its associated tags. We observed NMF on tags *revealed categories corresponding to traditional RPG roles and characteristics commonly associated with them.* For example, when $k = 2$, two types of characters are depicted, the first being "generally smart and fast moving" (rogue) and the second "strong, tough, and powerful." (fighter). As k increases, we observe more varied and nuanced roles. For eample, when $k = 4$, we have the "clever and wise" cleric, "strong and powerful" fighter, "intelligent and agile" rogue and "smart, charistmatic, and cunning" thief. Some tags corresponded with the name of attributes (e.g., strong, intelligent, and wise). NMF thus modeled how players used tags for describing a character's personality and characteristics that implicitly categorized them into well-known roles and classes found in other systems and videogames.

5.3 Stories in Text Descriptions

Results from NMF on data set $V_{descriptions}$ are shown in Table 3 above. We observed that *text descriptions appeared to be used for describing different, but identifiable kinds, of storyworld narratives* [11], such as character origins, relationships, and environment. This differed from tags, which were mainly used to further describe personality, traits, and characteristics. For example, when $k = 2$, topic 1 has terms that reflect social relationships like "family" and "parents" while topic 2 has terms that describe the surrounding environment like "town," "village," and "land." As k increases, the

k	factor	words *(in order of decreasing weights)*
2	1.	family young parents smart girl
	2.	town magic village land life
3	1.	family young parents smart girl
	2.	town save village daughter farmer son
	3.	magic mage land world far
4	1.	family young parents smart woman
	2.	town daughter soldier farmer home
	3.	magic mage powerful land far
	4.	village people save world left

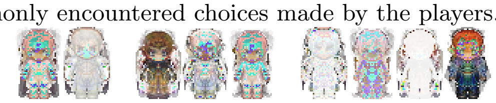
Table 3: Base factors obtained from non-negative matrix factorization on textual descriptions.

topics become more narrow in focus and disjoint from each other. For example, when $k = 4$, topic 1 seems to describe "personal/family relationships," topic 2 describes "realistic surroundings and professions" topic 3 describes "fantastical and fictional professions," and topic 4 describes "story arcs and goals." We list some top-weighted for each topic:

1. "*James is from a noble family.*"
2. "*Esrin is a former soldier who retired and became a farmer. He is reluctant to leave his land again but will do so for the good of his home town.*"
3. "*Lavellan is a mage, researching magic as a travelling freelancer.*"
4. "*Just an all round bad <expletive>, people in the village have always looked over her, but now it's her time to shine and save the day.*"

5.4 Characteristics of Avatar Basis Images

To analyze the results of performing NMF on the data set V_{images}, resultant basis vectors were recomputed into their *basis images* (Figure 1). We observed that some of the recomposed *basis images have characteristics that can be associated with idealized genders for the game.* For example, when $k = 2$, the two images resemble silhouettes of female and male characters, shown in Figure 1(a). These silhouettes also occur $k \geq 2$. As k increases, some basis images feature more gender neutral characteristics, like the first basis image in Figure 1(b) and the fourth basis image in Figure 1(c). Also, some basis images appear to *feature portions of the character outside their main bodies.* For example, the third image in Figure 1(c) has wing-like features, which were commonly encountered choices made by the players.



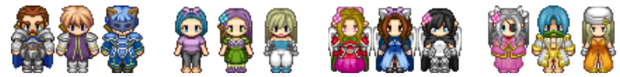
(a) $k = 2$ (b) $k = 3$ (c) $k = 4$

Figure 1: The sub-figures above show the basis images obtained for different values of desired basis vectors k from non-negative matrix factorization.

To concretely illustrate these findings, we show a set of three top-weighted images for each basis image for $k = 4$ in Figure 2. We observe that the *basis images represent "ideal" prototypes of the types of avatar images within them.* While basis images *provide a means to reveal certain discernible visual characteristics like distinct body types and hair styles that correspond to gender*, some are more abstract and difficult to interpret. However, these results on images provide interesting takeaways of how NMF performs on images compared to other computational representation components.

6. LIMITATIONS & FUTURE WORK

In this section, we outline limitations of our this work and suggest next steps for future work and directions. Firstly,



(a) (b) (c) (d)

Figure 2: The figures show top-weighted samples after non-negative matrix factorization for 4 base factors. Each factor's images share characteristics like distinct gender-associated features (a,b), having accessories like wings (c), or unusual visuals (d).

we observed that as the number of specified basis vectors k for NMF increased, interpreting each resultant basis vector became more challenging. Several methods for improving interpretation would be Convex hull Non-negative Matrix Factorization (CH-NMF) [19] and Archetypal Analysis (AA) [3]. Secondly, the participants for this study came from the social news site `/r/samplesize`, which inevitably skews the data set toward younger, more technology-savvy individuals. This was appropriate for our aims to gain insight into the everyday behaviors of people, which did not necessarily require them to play a lot of games. However, it is worth considering that those familiar with games might have alternative reasons for creating avatars that exhibit stereotypes. Our preliminary results from participants' BIG-5 International Personality Item Pool (IPIP) [6] personality data showed differences showed personality differences in based on players' gender [16], studying the relationship between personality and these NMF models could reveal useful insight into players. Thirdly, the genre and style of the avatar customization interface was that of a traditional RPG setting, with a fantasy-oriented 16-bit art style (that would now be considered retro graphics). Perhaps given a different genre or setting (e.g., space exploration, social simulation), the behaviors of these players would differ. We intend to integrate *AIRvatar* into different avatar customization systems. Lastly, we seek to enable players to use their characters within a videogame scenario and use the constructed models to dynamically adapt the experience for them.

7. CONCLUSION

In this paper, we have presented an approach to modeling the socially and culturally salient categories that players identify with, along with values they associate with them, through their virtual representations. This was achieved by analyzing data collected from 191 players who created avatars using an avatar customization system. Using non-negative matrix factorization (NMF), we: (1) discovered that players created avatars that reflected common real world stereotypes like a strong character consistently having low wisdom, (2) found that tags were mainly used to describe avatars characters based on prototypical RPG roles, (3) modeled how players created different types of background stories for their characters and (4) discovered that images of avatars could be decomposed to sub-images that revealed gender-related and accessory choice characteristics. We showed how players make use of different computational components for constructing virtual identities, and how their external knowledge, beliefs, and values may be revealed and computationally modeled using NMF for critical assessment.

8. ACKNOWLEDGMENTS

This material is based upon work supported by the National Science Foundation under Grant No. 1064495.

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