Creating Crowd Characters Through Procedural Deformation

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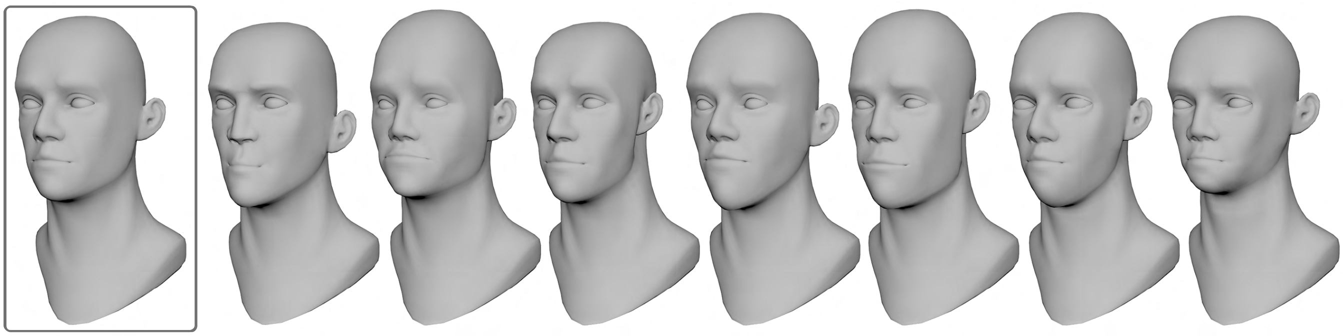

Figure 1: A collection of the facial mesh results produced by the system implemented in this work. Each is a unique plot in the full 64 dimensional parametric space of the procedural deformation system. The framed face is the base facial mesh.

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1 INTRODUCTION

The traditional processes employed for modeling characters are expensive and impractical for creating crowd character models, leading to the development and use of combinatorial methods [Dirksen et al. 2012]. While combinatorial methods are effective at creating large numbers of unique character variations, they lack the flexibility to create characters outside the finite range of possible combinations. This limitation is particularly troublesome in production circumstances that entail frequent fluctuations in character asset requests and real-time interactive experiences. In terms of real-time interactive experiences, this problem is primarily the result of the difficulty to predetermine the various states in which crowd characters are rendered. One common example of this can be seen in the standard practice of creating versions of a single character with varying levels of detail (i.e., LODs) that can be interactively toggled between depending on the distance between a user and a character. Because it is difficult in interactive experiences to control the render states a character will be subjected to at any given moment, LOD systems have been developed to optimize the resolution of a character model for various render states. Similar to the need for higher fidelity character models in render scenarios entailing close proximity between the user and character, greater visual uniqueness and distinctiveness are needed for crowd characters in such scenarios. While methods exist to restrict the control users have of the virtual camera in interactive experiences, thereby increasing the predictability of the render states for crowd characters in these contexts, these methods create limitations in terms of what possible stories are depictable in a real-time medium.

To allow for such real-time stories and greater flexibility in changing production scenarios, this work explores a procedural, parametrically driven system for creating crowd character facial models. This system uses craniofacial anthropometric data - sourced from existing literature - to create a multidimensional parametric structure from which procedurally randomized values can be generated and selected. Once new parameter values are generated, a base craniofacial model is deformed accordingly, resulting in a unique model that represents the parameter values assigned. The results of this method demonstrate the ability of a procedurally driven, craniofacial anthropometric facial deformation system to rapidly and efficiently create a large set of unique crowd character facial models that share a single UV map and polygonal topology. The results of this research indicate such a procedurally driven crowd character creation system would provide artists with the flexibility to quickly iterate and produce desirable results in scenarios such as interactive games. While the focus of this work is intentionally limited to facial models, these results provide sufficient evidence that a similar anthropometric method can be applied to the creation of full-bodied character models.

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2 APPROACH

The system developed in this work interprets a data set containing consolidated craniofacial anthropometric information [see Farkas

1994; Farkas et al. 2005; Marazita et al. 2017] to procedurally generate reasonable quasi-random parameter values that emulate craniofacial anthropometric measures (i.e., Maximum Cranial Width, Orbit Height, Nasal Protrusion, Labial Fissure Width, etc...). Each parameter determines the spatial distance between a unique pair of landmarks. As used herein, landmarks are biologically meaningful and salient morphological features of facial anatomy that are used as structural reference points to ensure inter-model correspondence (i.e., nasion, endocanthion, vertex, gonion, etc...). Once a new value is generated for each parameter in correspondence with input from a user and the consolidated craniofacial anthropometric data, a series of calculations are performed to determine new translation values for each landmark. The landmark set drives a uniquely authored deformation system that is composed of three unique sub-systems (see Figure 2). Each sub-system is designed to effectively address a specific and unique deformation objective. This is necessary due to the variation in the total surface area that each parameter affects, such that some parameters have a more global influence on the facial deformation and others have a more local influence.

The results produced by the implemented system in this work illustrate that the method explored is effective in producing crowd character facial models that exhibit substantial variability. In addition, the results demonstrate this method to be significantly more expedient at producing faces of notable uniqueness in comparison to the traditional process used for modeling faces. The ability to quickly create considerable uniqueness facilitates an artist's ability to iterate within the modeling process. By proceduralizing the shaping of a human facial model, an artist is able to quickly generate a unique result that differs from the previous model. In addition to workflow optimization, the system provides unique storytelling opportunities for real-time interactive experiences in which users control how and when they interact with crowd characters. With some additional development, the proposed system could be integrated into interactive experiences to allow for crowd character models to be deformed dynamically in real-time. This would allow the visual uniqueness of any crowd character to be enhanced to that of a hero character, thereby enabling unique choices and interactions for the user.

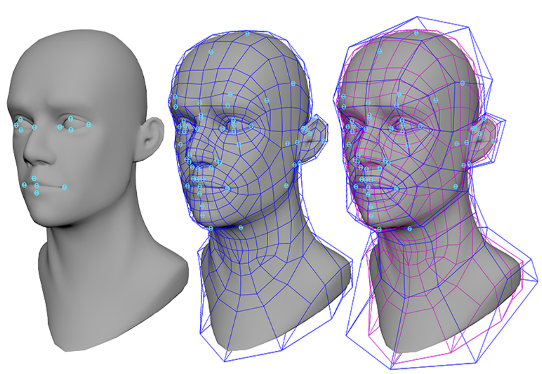

Figure 2: The three sub-systems of the full deformation system. Left: Orbital and Labial Fissures. Center: Locally Focused. Right: Globally Focused.

Figure 3: Array of different dual-parameter plots demonstrating the result of limitations on the system's robustness

The method presented here differs from other existing facial model synthesis systems such as FLAME [Li et al. 2017] and FaceScape [Yang et al. 2020] in that it is significantly more artistically directable. While the specific implementation of this system may not be suitable for all visual styles, it can be refitted to other base facial models of different visual styles with relative ease. Additionally, the parameters of the system presented here are intuitive for an artist to manipulate for the purposes of quickly refining the system's procedurally generated results. Both FaceScape and FLAME are facial model synthesis systems developed through machine learning and while powerful, it is difficult to manipulate systems such as these to effectively interpret input material that differs from the data sets used to train the systems.

In addition to these findings it was observed that although effective, insufficiencies in the existing, publicly available craniofacial anthropometric data undermined the system's robustness (see Figure 3). This issue is akin to situations in which artifacts, such as aliasing and distortion, are produced when complex continuous signals are reconstructed from limited discrete sample sets. Specifically, two key limiting factors were identified. The first being a lack of complete three dimensional data for each landmark and the second being the lack of fidelity and nuance currently measured in standard craniofacial anthropometric studies. With further research, these limitations could be mitigated and the fidelity of the system enhanced. Despite the deficiencies of the existing data used to drive this system, the benefit of using craniofacial anthropometric data in this application is that the "realism" of the resulting faces is somewhat built-in to the system being that the automated generation is constrained by the parameter ranges in the database.

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