3D content creation exploiting 2D character animation

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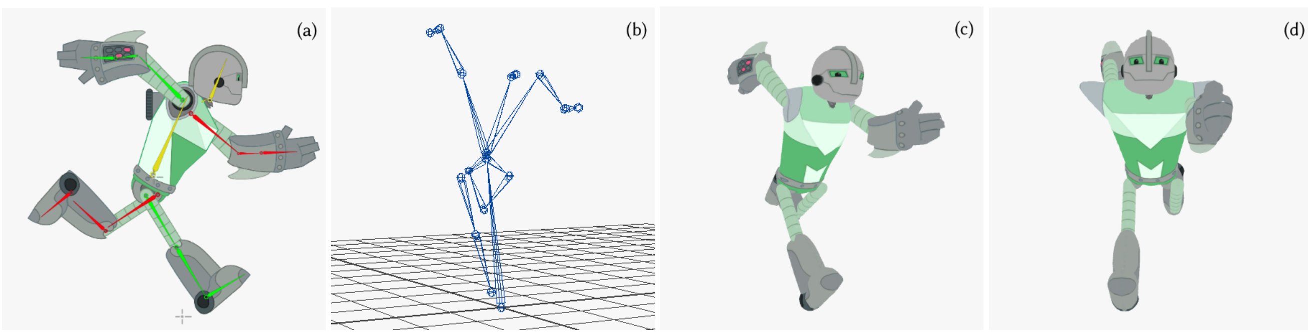

Figure 1: Stages of the generation of a 3D character animation from a frame of the input 2D animation (a). (b) shows the computed 3D skeleton. (c) and (d) show a frame of the converted 3D animation from the side and from the front. ©Thud Media

CCS CONCEPTS

• **Computing methodologies** → *Animation*; *Shape modeling*;

KEYWORDS

animation, modeling, surface registration, 3D representation

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1 INTRODUCTION

While 3D animation is constantly increasing its popularity, 2D is still largely in use in animation production. In fact, 2D has two main advantages. The first one is economic, as it is more rapid to produce, having a dimension less to consider. The second one is important for the artists, as 2D characters usually have highly distinctive traits, which are lost in a 3D transposition. An iconic example is Mickey Mouse, whom ears appear circular no matter which way he is facing.

While other systems [Kitamura et al. 2015; Rivers et al. 2010] use 2.5D models, which move 2D elements in 3D to simulate the three-dimensionality of the characters, in this paper a new system is proposed for the generation of 3D content by using existing 2D character animations, and therefore could be easily integrated into the current production pipeline. In fact, the system is fully automatic and all the assets required to work usually are directly available from the 2D animation production pipeline. Minimal intervention is required only if the body parts (figure 2), are not provided from multiple perspectives. The aim of the system is to maintain the characteristics of the 2D character in the 3D environment.

2 METHODOLOGY

2.1 Generation of the 3D model

The first stage of our system is the modelling of the 3D character. To maintain it as similar as possible to its 2D version, an approximated 3D model is generated for each provided 2D image of the character's turnaround.

First, a 2D mesh is generated for each body part of the character. Then, according to [Olsen et al. 2011], the flat mesh is inflated by using the distance of each point from the contour. The inflated mesh is then mirrored to obtain a closed 3D mesh. Figure 3 shows this process. The generated 3D components are then combined to form the complete 3D character. If the character has been provided drawn from multiple perspectives, along with the 2D skeleton for each point of view, the system places each body part in 3D. If only

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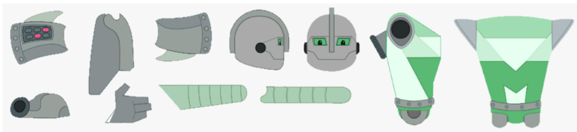

Figure 2: The character is provided split into several body parts from the existing pipeline. Otherwise, a minimal manual effort is required. ©Thud Media

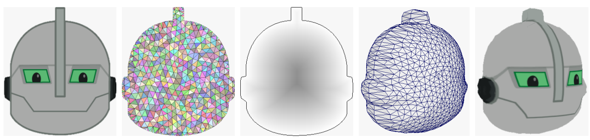

Figure 3: The modelling process of the system. ©Thud Media

one image and one 2D skeleton have been provided, then user input is required.

2.2 Surface registration

For the body parts for which the user has provided multiple perspectives, to maintain all the character's features visible from different perspectives, a novel non-isometric surface registration method is proposed, inspired by the work of [Jiang et al. 2017].

Given a template mesh $\mathcal{S}$ and a target model $\mathcal{T}$, the goal is to deform the template $\mathcal{S}$ gradually into $\mathcal{S}'$ so that the deformed mesh $\mathcal{S}'$ is sufficiently close to the target $\mathcal{T}$ with structure preserved and feature points matched. Let p, p', q denote the vertex positions on $\mathcal{S}, \mathcal{S}', \mathcal{T}$ respectively, the registration energy is defined as:

$$E(p') = w_l E_l(p') + w_d E_d(p') + w_c E_c(p') + w_f E_f(p'), \quad (1)$$

where E_l is the bi-Laplacian energy, E_d is the consistent as-similar-as-possible (CASAP) energy, E_c is the correspondence constraint energy, and E_f is the feature point constraint energy. The weights before each energy term adjust the influence they account for in the total energy.

The matching points between the two adjacent perspectives are computed before converting the images into 2D meshes. As in the current 2D animation pipeline the body parts are separate, feature points as the eyes or the mouth can be easily detected.

The registration is computed between all the couple of models generated from adjacent perspectives in both ways: using one as the template and the other as the target, and vice versa. In the system, the model of the closest perspective is shown. While the camera rotates around the character, the position of the vertices is interpolated between their position in the source model and in the registration. The registration result can be seen from the supplemental video.

2.3 Generation of the 3D animation

The system computes automatically a 3D skeleton only for the first frame of the animation, using the provided 2D skeletons. If only one side is provided, then the joints must be placed manually on the z axis. To bind together the skeleton and the model, the system applies a *rigid skinning*.

Once obtained the 3D skeleton for the initial binding pose, the system computes the 3D animation by reconstructing the 3D poses for each keyframe of the 2D animation. Inspired by the works of [Barbieri et al. 2016], a new optimization method is introduced to convert the 2D animation. The 2D skeleton is sampled to obtain the set of 2D points $Y = (y_1, y_2, \ldots, y_M)$. The same sampling is applied to the 3D skeleton, to obtain the same number of points $V = (v_1, v_2, \ldots, v_M)$ and thus a one-to-one correspondence between the points in the two sets.

The objective is to find the rigging parameters p which deform the points in V as closely as possible to those in Y. The optimization problem is defined as:

$$\arg\min_{p} \sum_{i=1}^{M} \|y_i - \mathbf{C} \cdot v_i(p)\|_2^2 + \Phi(p) \quad (2)$$

where $\mathbf{C} \in \mathbb{R}^{2\times3}$ is the camera projection matrix, which is used to compare the points in Y with the projection of the points in V. $\Phi(p)$ is a regularization term which have two purposes: to penalise solutions without the least amount of change compared with the initial pose and to promote solutions which keep the deformed point in V in the same viewing plane.

The optimization problem is solved for each keyframe, while the other frames are interpolated.

3 CONCLUSIONS

In the paper, a new system to generate 3D content by exploiting 2D character animations has been presented. The system is able to generate a 3D character from 2D images, with a minimum intervention of the drawer in the input drawings. Moreover, it is able to convert 2D animations into 3D automatically, allowing the users to repurpose old animations or to keep working with 2D. Figure 1 shows a frame of a running animation of a 2D character and the generated 3D version from two different points of view. Additionally, the supplemental video shows an overview of the entire process.

Our system not only has the advantage to keep the converted 2D characters highly recognizable even in 3D, due to the applied registration method, but also has the economic advantage to reuse drawing and animations from their 2D versions. There are several application for our system. First, it could be used to repurpose 2D character animations from animated film or shows to make video games or other kind of 3D applications. Secondly, it could be used to bring 2D characters into Virtual or Augmented Reality, which are increasingly popular.

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