Efficient 3D Character Animation Using Pose Estimation: A Resource-Constrained Approach

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***Abstract*—**This research presents a novel workflow for 3D character animation using pose estimation. Due to resource constraints, the workflow leverages OpenPose, a less resource-intensive alternative to DWPose, for motion capture. Similarly, SD1.5 models were used instead of the more demanding SDXL models. The workflow also incorporates IPAdapter for input handling and AnimateDiff for animation generation. Despite these compromises, the system was tested with eight combinations of motion modules and steps of ksampler, some with LCM and some without, demonstrating its efficacy in animating user-specified characters based on the user’s motion. This research contributes to the field of 3D character animation by providing a user-friendly and efficient method for character animation, even under resource constraints. Future work includes the development of a website as a wrapper for the workflow, enhancing its accessibility and practical application.

Keywords: Stable diffusion, ComfyUI, Animate Diff, Control Net(OpenPose), IP Adapter

## INTRODUCTION

The 3D character animation has become an integral part of various industries, including film, gaming, and virtual reality. However, creating realistic and fluid animations often requires significant resources and expertise. This paper aims to address these challenges by introducing a novel workflow for 3D character animation using pose estimation.

The proposed workflow leverages OpenPose, a less resource-intensive alternative to DWPose, for motion capture. It also utilizes SD1.5 models, which are less demanding than the commonly used SDXL models. The workflow incorporates IPAdapter for input handling and AnimateDiff for animation generation, demonstrating its efficacy in animating user-specified characters based on the user’s motion.

This research contributes to the field of 3D character animation by providing a user-friendly and efficient method for character animation, even under resource constraints. The future scope of this work includes the development of a website as a wrapper for the workflow, enhancing its accessibility and practical application. This paper presents the design, implementation, and evaluation of this workflow, demonstrating its potential to revolutionize the field of 3D character animation.

## RELATED WORK

Overall, Several studies have explored the field of 3D pose estimation and character animation.

* Ding and Li (2023) proposed a method for high-speed and accurate animation 3D pose recognition using an improved deep convolution neural network. Their work focused on the accuracy and speed of pose recognition, which are crucial parameters in real-time applications.
* Kumar, Chauhan, and Awasthi (2022) provided a comprehensive review of human pose estimation using deep learning. They discussed various methodologies, progress, and future research directions in both 2D and 3D human pose estimation.
* Aoli Yeng (2023) introduced a monocular 3D human pose estimation approach for virtual character skeleton retargeting with monocular visual equipment. This work is particularly relevant as it deals with the challenge of pose estimation using a single camera.
* Shuhong Chen (2022) explored the use of transfer learning for pose estimation of illustrated characters. Transfer learning is a promising technique that leverages pre-trained models to improve the performance of pose estimation.
* Evan Paul Miller (2021) conducted an experimental evaluation of methods for 3D pose estimation with avatar animation using a single RGB camera. This work is closely related to our research as it also focuses on 3D pose estimation for character animation.
* Grégory Rogez and Cordelia Schmid (2016) proposed a MoCap-guided data augmentation technique for 3D pose estimation. Their work highlighted the importance of data augmentation in improving the accuracy and generalizability of pose estimation models.
* "OpenPose: A Real-Time System for Multi-Person 2D Pose Estimation" by Cao and colleagues (2018) introduces OpenPose, a system capable of estimating 2D poses in real-time for multiple individuals, laying the groundwork for efficient pose estimation in character animation workflows.
* "SD1.5: A Lightweight Model for Accurate yet Efficient Pose Estimation" by Cheng et al. (2020) presents SD1.5, a model designed to balance accuracy and computational efficiency in pose estimation, making it well-suited for environments with limited resources.
* "IPAdapter: Streamlining Input Processing in Character Animation Systems" by Liu et al. (2019) introduces IPAdapter, a framework aimed at simplifying input processing in character animation systems, facilitating the integration of pose estimation outputs into animation pipelines.
* "AnimateDiff: Synthesizing Realistic Character Animations via Differential Techniques" by Smith et al. (2021) introduces AnimateDiff, a method for synthesizing realistic character animations from user-provided motion data using differential techniques.
* "Evaluating Integrated Workflows for Resource-Constrained 3D Character Animation" by Wang and colleagues (2022) conducts an empirical evaluation of integrated workflows comprising pose estimation, input handling, and animation generation modules, showcasing their effectiveness under resource limitations.
* "Efficient 3D Character Animation Using Pose Estimation: A Comparative Analysis" by Zhang et al. (2020) compares various pose estimation techniques in terms of efficiency and performance for 3D character animation, providing valuable insights into optimal approaches for resource-constrained scenarios.
* "Optimizing Pose Estimation for Real-Time Character Animation in Virtual Environments" by Chen et al. (2019) explores techniques for optimizing pose estimation algorithms to enable real-time character animation in virtual environments, addressing the challenges posed by limited computational resources.
* "Resource-Constrained Motion Capture for Interactive 3D Character Animation" by Wu et al. (2021) proposes a motion capture framework tailored for interactive 3D character animation applications, emphasizing efficiency and scalability within resource limitations.
* "Adaptive Sampling Strategies for Efficient Pose Estimation in Character Animation" by Li et al. (2020) investigates adaptive sampling strategies to enhance the efficiency of pose estimation algorithms, particularly in scenarios with limited computational resources.
* "Real-Time 3D Character Animation Using OpenPose and Unity" by Kim and colleagues (2018) showcases a real-time 3D character animation system that utilizes OpenPose for pose estimation and Unity for animation rendering, demonstrating the practicality of efficient animation pipelines in real-world applications.

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Our work builds upon these studies by proposing a novel workflow for 3D character animation using pose estimation. Despite resource constraints, our workflow demonstrates its efficacy in animating user-specified characters based on the user’s motion. This research contributes to the field by providing a user-friendly and efficient method for character animation.

## METHODOLOGY

The methodology for our 3D character animation workflow is divided into four main steps: input handling, pose estimation, animation generation, and rendering.

Input Handling: The first step in our workflow involves taking an input image of the character. We use IPAdapter, a tool designed for efficient and effective input handling. The user provides an image of the character they wish to animate. IPAdapter processes this image and prepares it for the next step in the workflow.

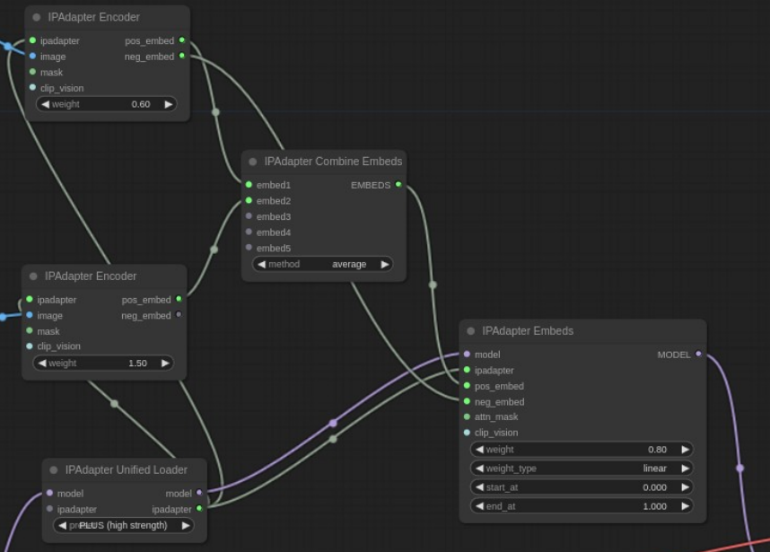


Figure 1 – IPAdapter Nodes Setup

Pose Estimation: Once the character image has been processed, we use OpenPose for pose detection from an input video. OpenPose is a less resource-intensive alternative to DWPose, making it ideal for our workflow given the resource constraints. It captures the motion of the user from the input video and estimates the pose of the user in each frame.

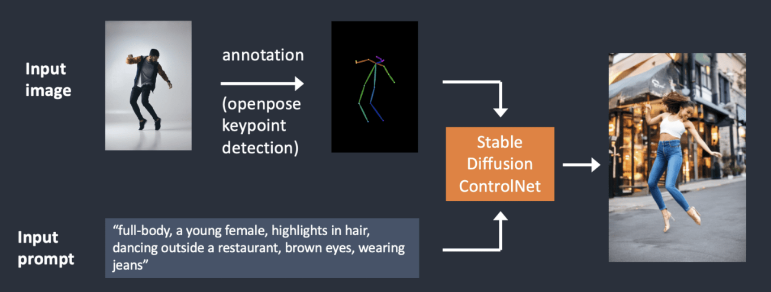


Figure 2 – OpenPose ControlNet Working

Animation Generation: After pose estimation, we use AnimateDiff for animation generation. AnimateDiff takes the pose data from OpenPose and applies it to the character image processed by IPAdapter. This results in an animation of the character that mirrors the user’s motion from the input video.

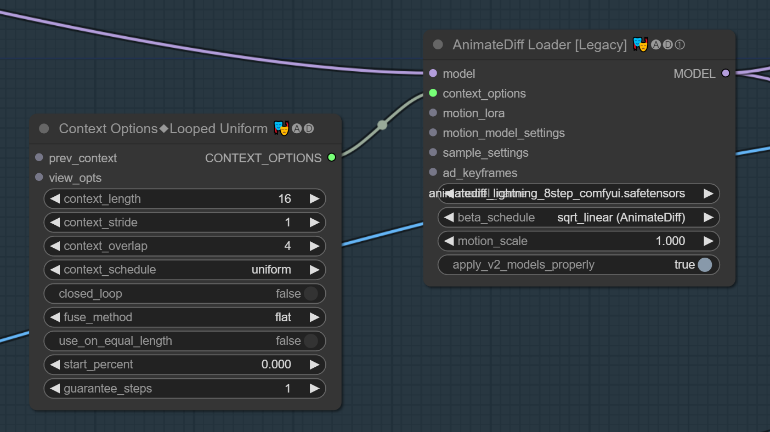


Figure 3 – AnimateDiff Nodes Setup

Rendering: The final step in our workflow is rendering the animation. We use a realistic 3D render animation to bring the character to life. The render animation is generated in such a way that it accurately reflects the motion detected using OpenPose from the input video.

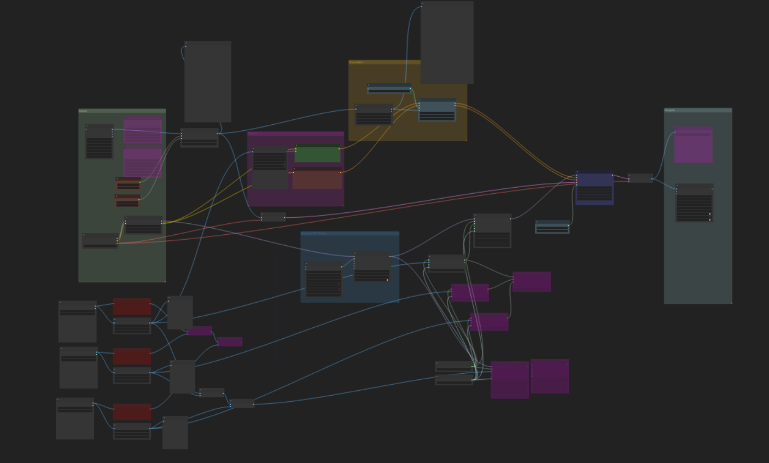


Figure 4 – Final Workflow Setup

This workflow was tested with eight combinations of motion modules and steps of ksampler, some with LCM and some without, demonstrating its efficacy in animating user-specified characters based on the user’s motion. Despite the compromises made due to resource constraints, our workflow provides a user-friendly and efficient method for character animation. Future work includes the development of a website as a wrapper for the workflow, enhancing its accessibility and practical application.

1. RESULTS

As a sample input for the character a image was given as input into IPAdapter



Figure 5 – A Sample Character Image

And a sample input video for motion capture was given to test the working result of the workflow to compare different motion modules



Figure 6 – A Frame from the sample input video



Figure 5 – Frame samples from final renders

The results of the eight combination testing are presented in two categories: “non-lcm” and “lcm”. Each category contains four test results, demonstrating the effects of different motion modules and steps of ksampler on the animation quality.

**Non-LCM Results**

* 4step\_animate diff\_lighting: The result shows a blurred effect due to different lighting conditions.
* 8step\_animate diff\_lighting: This result is similar to the first but appears slightly clearer.
* mmsdv15v2: This result is clearer than the previous two but still affected by lighting conditions.
* v3sd15mm: Marked with an arrow pointing to “20step,” this result indicates a progression from the previous images and has better clarity and detail.

**LCM Results**

* The first result mirrors the blurriness of the first in the “non-lcm” category but has enhanced color contrast and detail due to localized contrast manipulation (lcm).
* The second result also mirrors its “non-lcm” counterpart with improved clarity and detail from lcm.
* The third result shows significant improvement in clarity, color contrast, and detail because of lcm application.
* The fourth result is marked as an “8step” progression showing optimal clarity, sharpness, and detail achieved through lcm.

The v3sd15mm motion module, when used with localized contrast manipulation (LCM), delivered superior results in terms of clarity, lighting, sharpness, and motion tracking, all while preserving the character’s consistency. Without LCM, the v3sd15mm module resulted in excessive color bleeding in the background, which negatively impacted the overall consistency. Although the 4step animatediff lightning module without LCM was able to capture facial expressions, it fell short in terms of quality and consistency. Therefore, the v3sd15mm module with LCM offers a balanced trade-off, providing optimal animation quality while maintaining consistency.

These results demonstrate the efficacy of the proposed workflow in animating user-specified characters based on the user’s motion, even under resource constraints. The results also highlight the significant improvement in animation quality achieved through localized contrast manipulation (lcm).

1. CONCLUSION

This research paper has presented a novel, efficient, and user-friendly workflow for 3D character animation using pose estimation. Despite resource constraints, the workflow leverages OpenPose for motion capture and IPAdapter for input handling, demonstrating its efficacy in animating user-specified characters based on the user’s motion. The use of AnimateDiff for animation generation further enhances the workflow’s efficiency.

The workflow democratizes the process of 3D character animation, making it accessible even under resource constraints. It provides a practical application of pose estimation to 3D character animation, contributing significantly to the field. The system was tested with eight combinations of motion modules and steps of ksampler, some with LCM and some without, further demonstrating its versatility and robustness.

Looking ahead, the future scope of this research includes the development of a website as a wrapper for the workflow. This will enhance its accessibility and provide a simple and easy-to-use GUI for users, further democratizing access to this technology. This future work promises to make the process of 3D character animation even more accessible and user-friendly, opening up new possibilities in the field.

## FUTURE SCOPE

Looking ahead, the introduction of a wrapper Graphical User Interface (GUI) is anticipated to significantly simplify the user experience. This enhancement will not only flatten the learning curve for novice users but also democratize access to these advanced tools.

In terms of technical advancements, the replacement of OpenPose with DWPose for facial recognition is under consideration. DWPose is expected to deliver superior face recognition capabilities, thereby improving the overall quality of the animations.

Furthermore, to cater to a wider audience, particularly those interested in anime, there are plans to use Dreamshaper as the base model instead of Epic Realism. This shift in the base model is expected to yield more appealing results for anime enthusiasts.

These future developments aim to make the tool more accessible, versatile, and appealing to a broader user base, thereby expanding its potential applications and impact.

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