OmniPhotos: Casual 360° VR Photography with Motion Parallax

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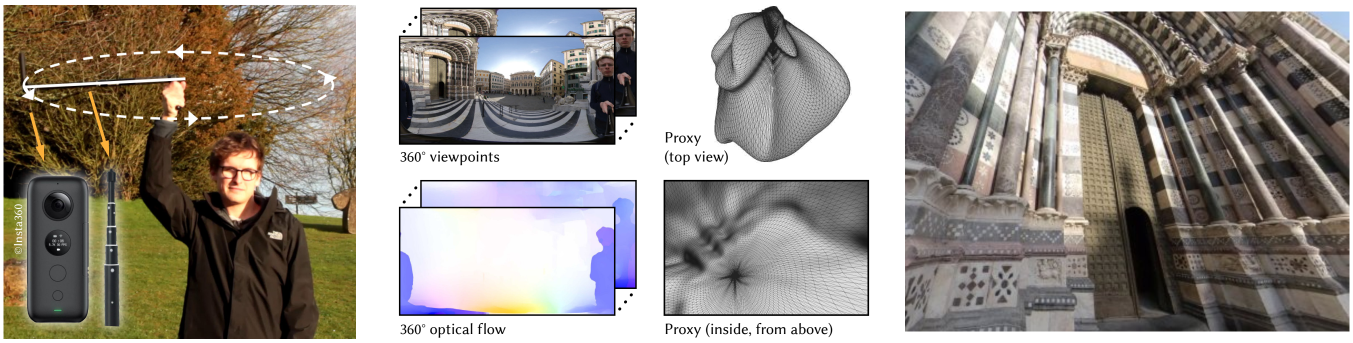

Casual capture in seconds   Image-based scene representation   OmniPhoto – 360° VR photograph

Figure 1: OmniPhotos are 360° VR photographs with motion parallax that can be casually captured in a single 360° video sweep. Capturing takes 3–10 seconds and, once processed into an image-based scene representation, OmniPhotos can be viewed freely in consumer VR headsets. *Please note that our figures are animated to best convey our results; please view with Adobe Reader.*

ABSTRACT

Until now, immersive 360° VR panoramas could not be captured casually and reliably at the same time as state-of-the-art approaches involve time-consuming or expensive capture processes that prevent the casual capture of real-world VR environments. Existing approaches are also often limited in their supported range of head motion. We introduce OmniPhotos, a novel approach for casually and reliably capturing high-quality 360° VR panoramas. Our approach only requires a single sweep of a consumer 360° video camera as input, which takes less than 3 seconds with a rotating selfie stick. The captured video is transformed into a hybrid scene representation consisting of a coarse scene-specific proxy geometry and optical flow between consecutive video frames, enabling 5-DoF real-world VR experiences. The large capture radius and 360° field of view significantly expand the range of head motion compared to previous approaches. Among all competing methods, ours is the simplest, and fastest by an order of magnitude. We have captured more than 50 OmniPhotos and show video results for a large variety of scenes. We will make our code and datasets publicly available.

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1 INTRODUCTION

The latest VR headsets enable amazing immersion thanks to 6 degree-of-freedom (6-DoF) tracking of the headset [Koniaris et al. 2016; Koulieris et al. 2019]. However, capturing 360° VR photographs that exploit the full potential of VR in terms of immersion, in particular depth cues like motion parallax, is currently beyond the average user [Richardt et al. 2019]. To fill this gap, we introduce a new approach for casual VR photography with a consumer 360° video camera that enables end users to capture immersive 360° VR photographs in less than 3 seconds (see Figure 1).

State-of-the-art 360° VR photography relies on panoramic light fields [Overbeck et al. 2018], which require the time-consuming capture and processing of more than a thousand input photos. This is clearly beyond the reach of most users. Hedman and Kopf's Instant 3D Photography approach [2018] reconstructs high-quality textured panoramic meshes from dozens of captured colour+depth images, with full 360° VR photographs requiring more than a minute of capture time. 3D reconstruction also remains fragile and prone to artefacts, e.g. for thin or distant objects in a scene. The MegaParallax approach [Bertel et al. 2019] overcomes this limitation using image-based rendering with view-dependent flow-based blending. The capture process is also more convenient as capturing an input video only takes about 10 seconds. However, the supported range of motion (*aka* head box) is limited by the field of view of the capture camera, and the basic proxy geometry introduces visual distortions.

We introduce OmniPhotos, which takes advantage of a consumer 360° video camera on a rotating selfie stick: (1) Capture time is reduced to less than 3 seconds, enabling truly casual 360° VR photography. (2) The omnidirectional field of view of 360° cameras unlocks a significantly enlarged viewing area. (3) We improve the visual fidelity of the VR viewing experience by automatically and robustly reconstructing a scene-adaptive proxy geometry.

Parallax360 [Luo et al. 2018] MegaParallax [Bertel et al. 2019] OmniPhotos (our approach)

Figure 2: Comparison of image-based 360° VR photography techniques for a virtual camera moving on a circle. Our results show high-quality view synthesis with motion parallax and reduced distortion. *Please view animated figure with Adobe Reader.*

2 OUR APPROACH

The input to our approach is one 360° video captured by a consumer camera 360° moving on a circular path. This can be achieved in just a few seconds (1.7 seconds on average) using a rotating selfie stick, as illustrated in Figure 1. We use an Insta360 One X camera[1] to capture 4K 360° video at 50 Hz. This approximately matches the angular resolution of current VR displays (11–14 pixels per degree). We use an exposure time of ≤1/2000 s to minimise motion blur.

We process a raw input 360° video by stitching it with camera stabilisation, and estimate camera poses and a sparse 3D point cloud of the scene using off-the-shelf SLAM software. We also precompute optical flow between pairs of adjacent images, directly on the stitched equirectangular images, which enables high-quality view synthesis at run time [Bertel et al. 2019]. Our main technical contribution is the computation of a scene-adaptive proxy geometry by robustly fitting a deformable spherical mesh to the reconstructed 3D points. Our proxy fitting technique is specifically tailored for our casually captured OmniPhotos, and robustly produces scene-adaptive proxy geometry that more accurately represents the geometry of the captured scene than simple planar or cylindrical proxy used before [Bertel et al. 2019]. Newly captured OmniPhotos can be processed in about 30–40 minutes on a standard computer (3 GHz 8-core CPU, 16 GB RAM, NVIDIA GeForce RTX 2060).

Our 360° VR photography viewer generates new viewpoints in real time given the location and orientation of the user's headset. Each new view is rendered by rasterizing the proxy geometry and computing the colour of each pixel independently and in parallel. Specifically, we use the direction of each pixel's camera ray in the desired view to find the optimal input camera pair for the pixel, and then project the proxy 3D point into both cameras. Finally, we apply view-dependent flow-based blending using the precomputed flow fields while explicitly handling the azimuth wrap-around. We implement our OmniPhotos viewer using OpenVR, which supports SteamVR, Oculus and Windows MR using the same code base. For more details, please see our parallel technical paper submission.

[1]https://www.insta360.com/product/insta360-onex (last accessed 22 June 2020)

3 EXPERIENCE

We have captured and processed more than 50 OmniPhotos in six countries across Europe and Asia. We show a selection of them in Figure 2 and our supplemental video, which gives a better impression of the visual experience. More OmniPhotos can be found in our online gallery. At SIGGRAPH Asia 2020, we invite attendees to join us on a journey across the world by demonstrating the OmniPhotos experience live. We also invite virtual attendees to experience our best and most immersive 360° VR photographs first hand using a downloadable demo (Windows only) that supports a wide variety of VR headsets as well as a normal windowed mode.

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