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VICTORIA UNIVERSITY OF WELLINGTON TE HERENGA WAKA
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Casual 6-DoF: Free-Viewpoint Panorama Using a Handheld 360 Camera

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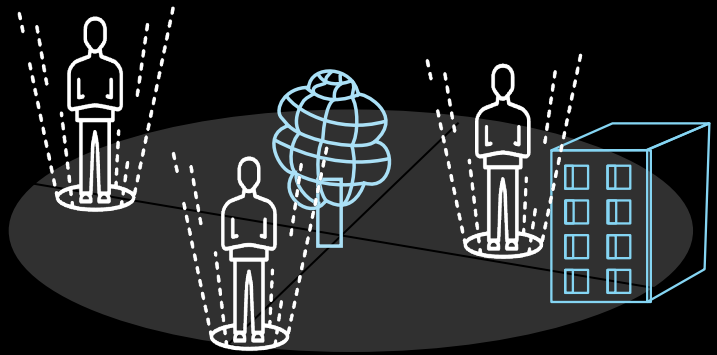
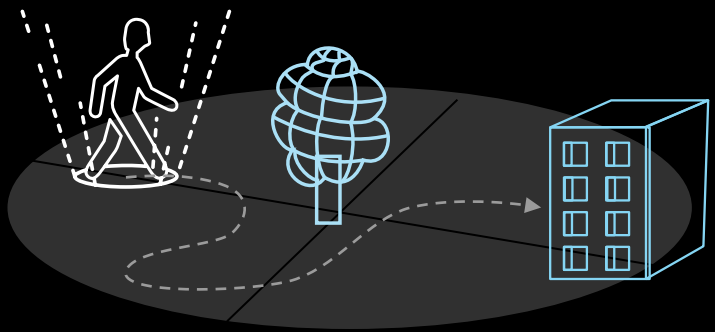
Telepresence with 360 Video

360 videos shown in VR display can provide a wide field of regards. This provides a sense of telepresence at the captured location

How to move around with telepresence ?



Jumping around



Walk around

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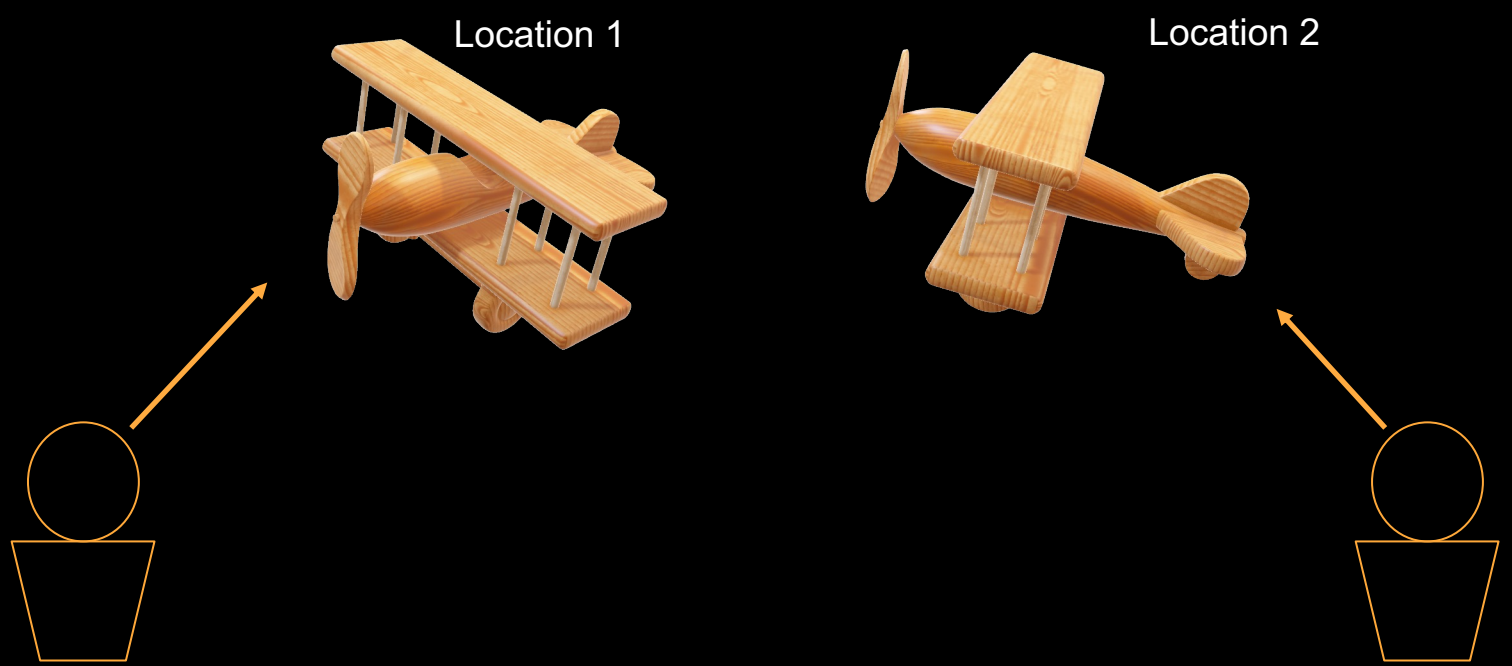
Novel view synthesis



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Capturing – perspective camera

Perspective Camera

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Capturing - 360 Camera

Perspective Camera

360 Camera

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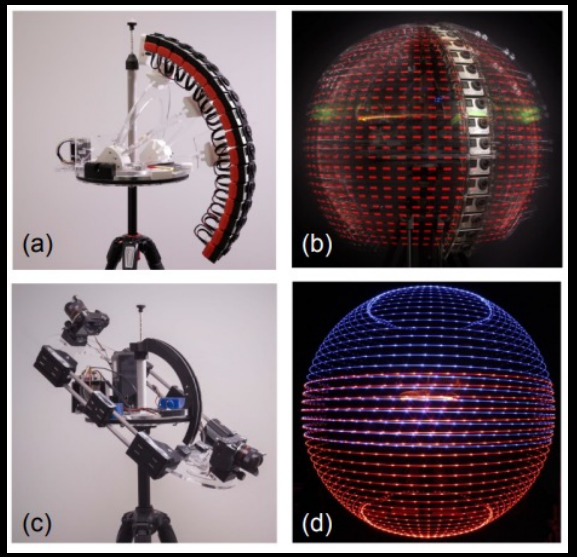
Related work panorama with special equipment

[Overbeck et al. 2018]



[Pozo et al. 2019]

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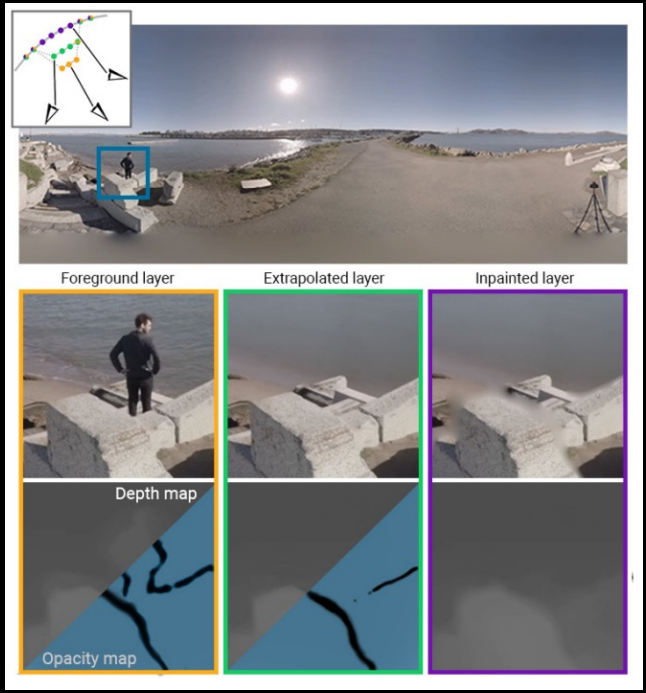
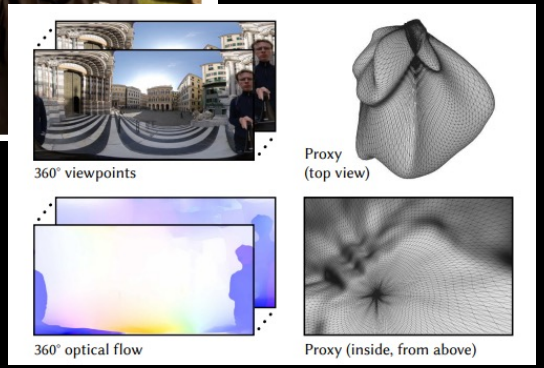
Related Work: 360 panorama

360 RGB-D Video (Serrano et al. 2019)



OnmiPhoto (Bertel et al. 2021)

5-DoF



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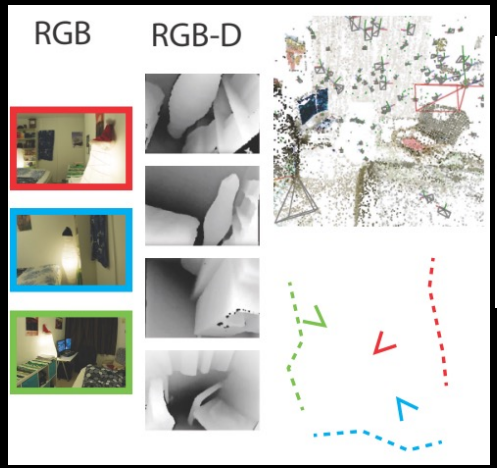
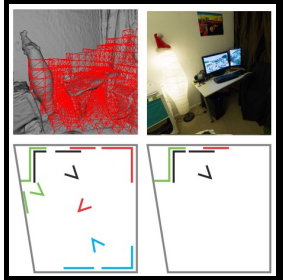
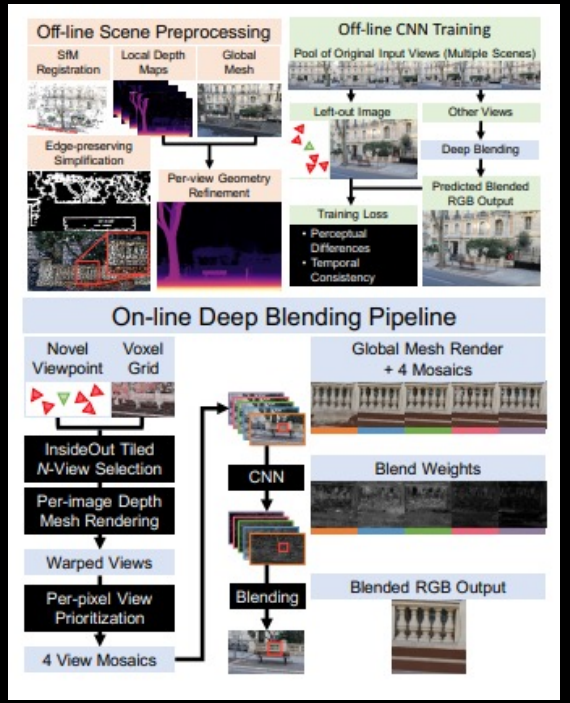
Related Work: Image base Rendering

Inside-Out (Hedman 2016)





Deep-Blending (Hedman 2017)



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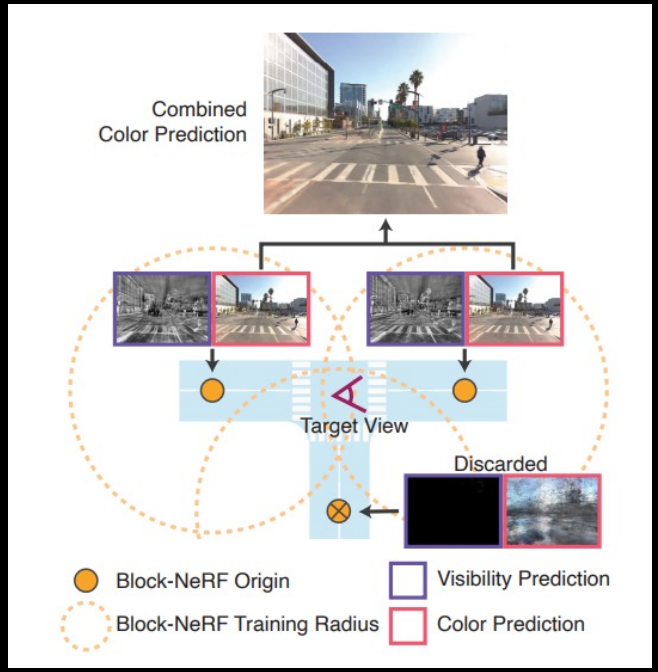
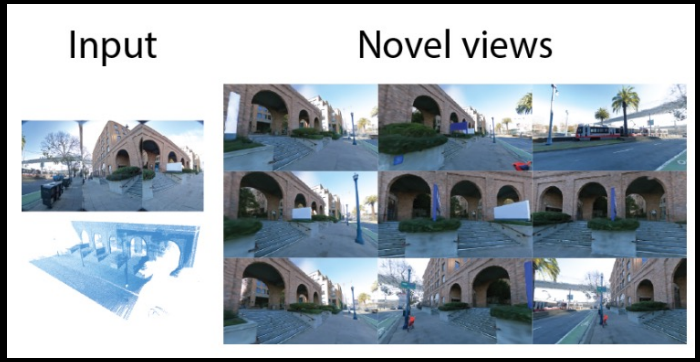
Related Work: NeRF

Block NeRF (Tancik et al. 2022)



Urban NeRF (Tancik et al. 2022)



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Our Contributions

- Novel complete pipeline that create 6-DoF viewing experiences using a single handheld consumer-grade 360° camera
- Robust approach to reconstruct the depth panoramas for RGB 360° panoramas
- Our novel-view synthesis method can be run in real-time (>30fps) to allow users to walk around within a large-scale captured scene

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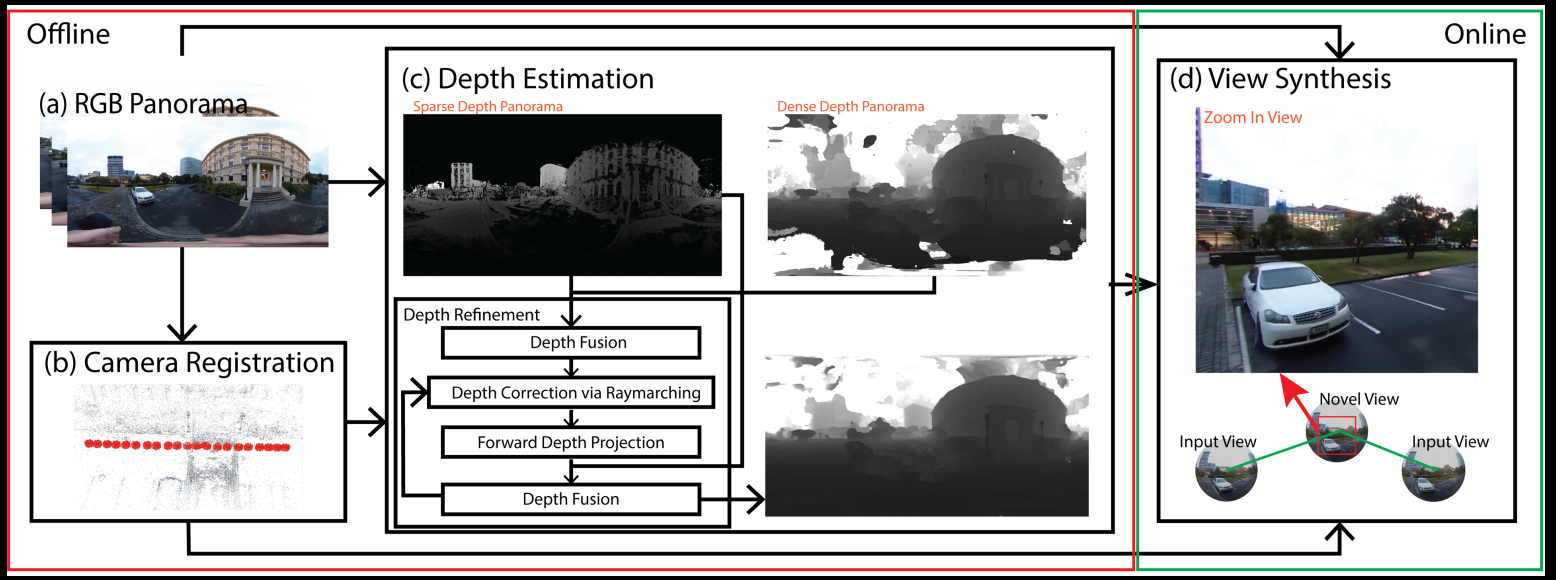
Pipeline Overview

1. Capturing and Registration
2. Depth Estimation
3. Novel View Synthesis



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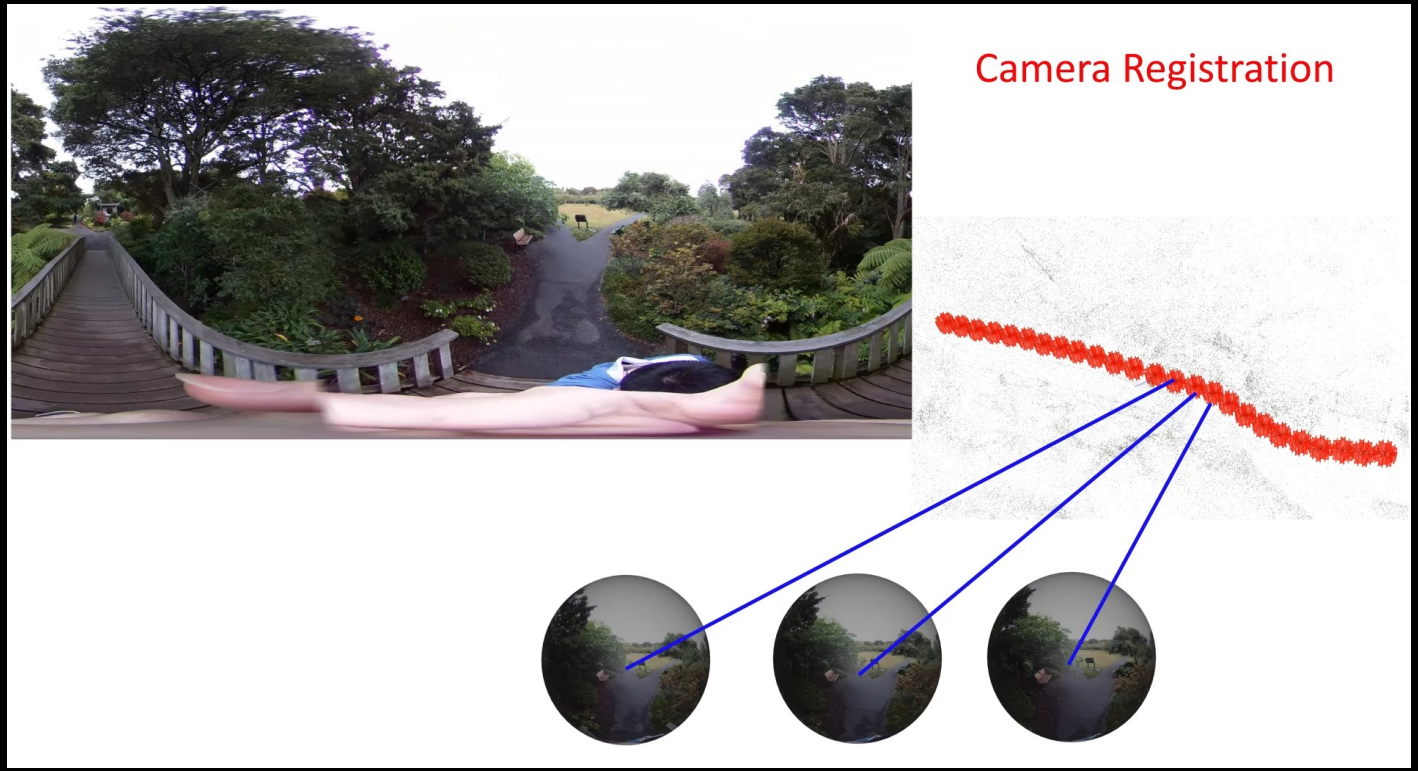
Camera Registration



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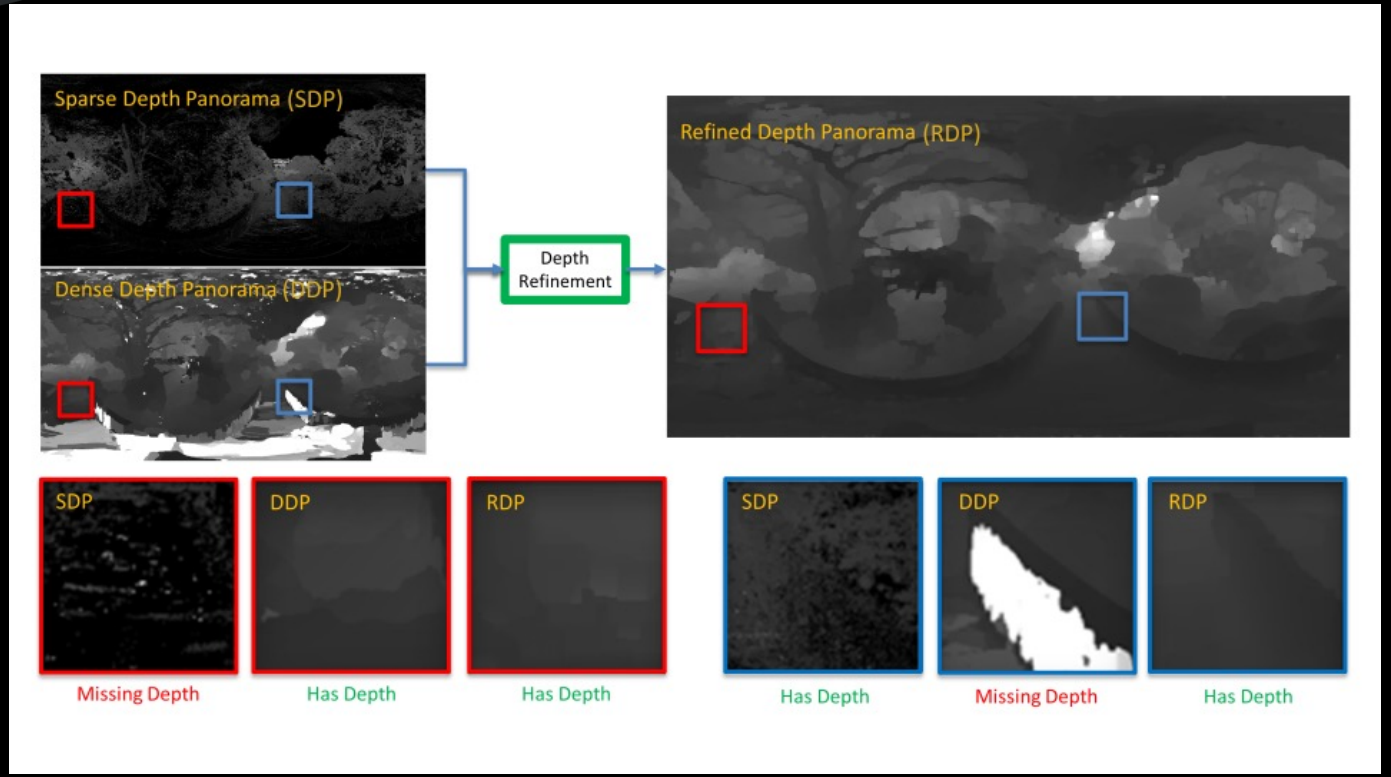
Depth Reconstruction



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Depth Refinement

- Initial Depth
- Depth Correction via Raymarching
- Forward Depth Projection
- Depth Fusion

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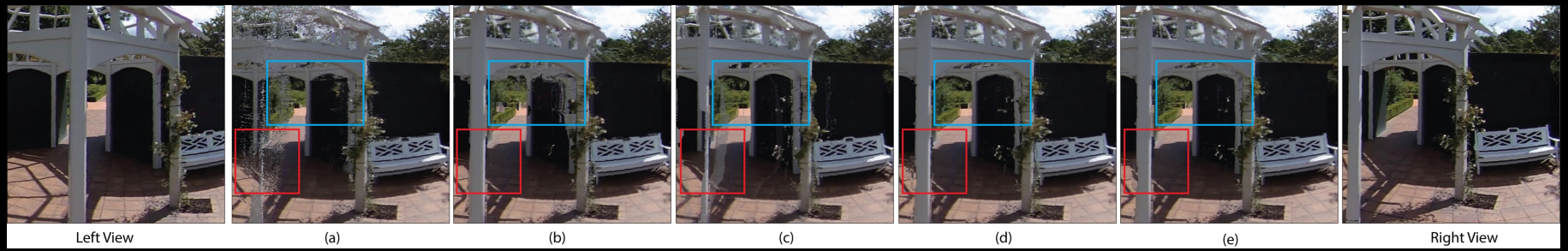
Depth Reconstruction Result



a) Sparse Depth Only
b) Combine Sparse and Dense Depth
c) After first refinement step
d) After second refinement step
e) Final refined depth

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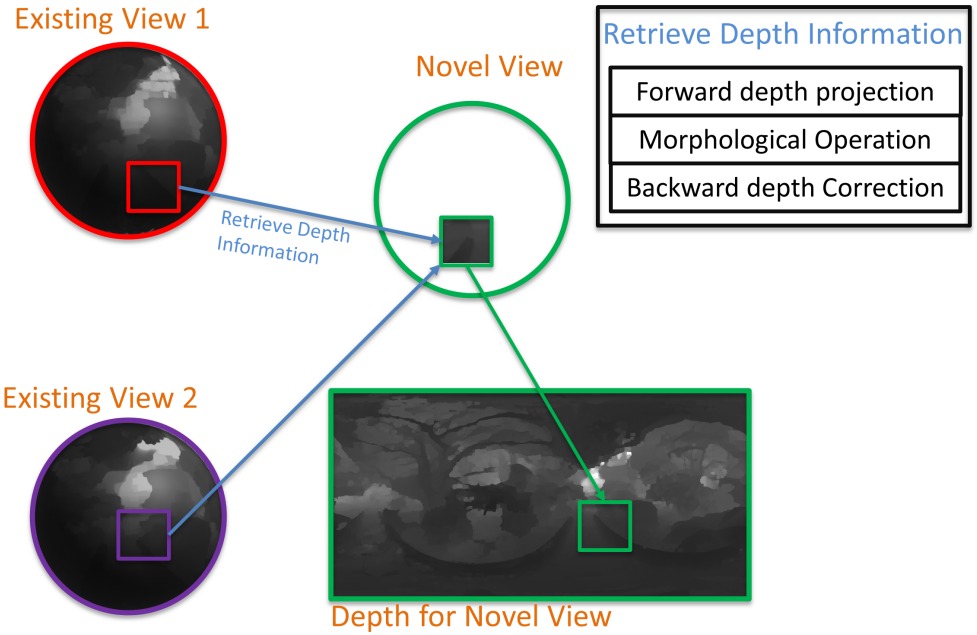
Novel view Synthesis - Depth



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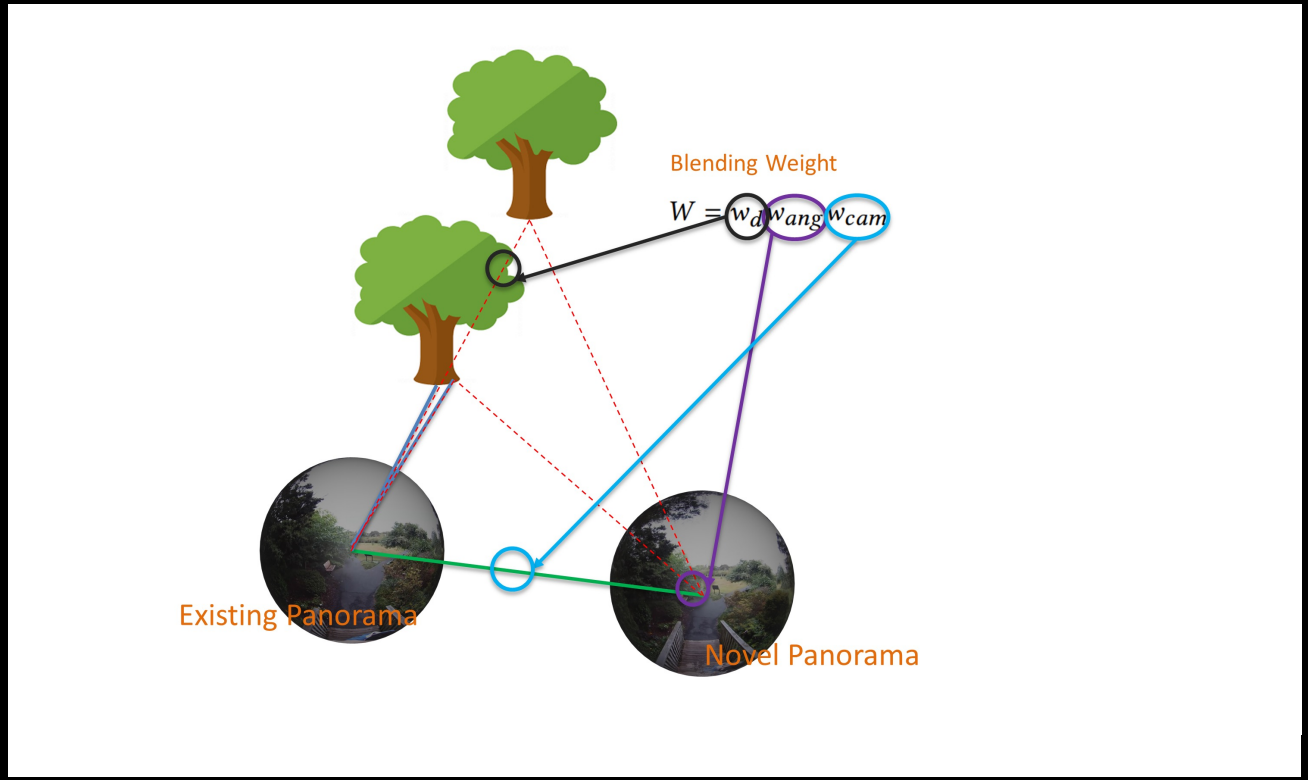
Novel View Synthesis - Colour



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Navigation using HMDs

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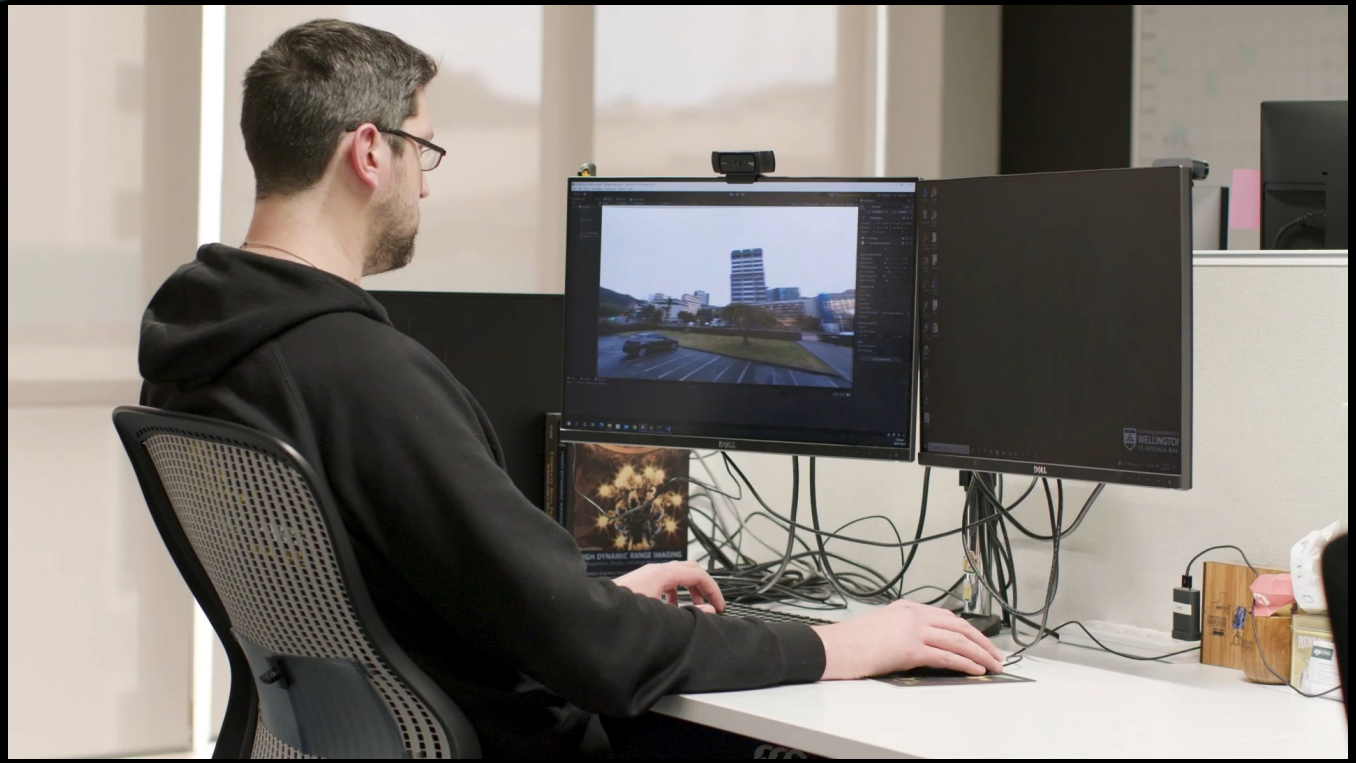
Scene Navigation in Game Engine



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Result

Visual Quality Comparison

Indoor Scenes			
	PSNR ↑	MS-SSIM↑	LPIPS↓
ULR	21.49	0.85	0.13
Inside-Out	22.51	0.85	0.08
DeepBlending	22.31	0.82	0.10
Our method with full process	**25.25**	**0.92**	**0.07**
Our with only sparse depth	14.74	0.68	0.19
Our with only dense depth	22.46	0.85	0.11
Our with only depth fusion	24.18	0.90	0.09
Outdoor Scenes			
	PSNR ↑	MS-SSIM↑	LPIPS↓
ULR	10.72	0.79	0.53
Inside-Out	17.3	0.74	0.18
DeepBlending	16.11	0.71	0.22
Our method with full process	**21.93**	**0.84**	**0.12**
Our with only sparse depth	11.12	0.50	0.33
Our with only dense depth	19.98	0.75	0.15
Our with only depth fusion	20.09	0.81	0.14

TABLE 2: Quantitative Comparison of our method with prior works and ablated version of our method. The score are the mean score over all scene indoor/our door scenes. ↑ means higher is better and ↓ means lower is better.

Pre-Processing Time Comparison

	Deep-Blending	Inside-Out	Ours
COLMAP	< 3 hours	< 3 hours	< 3 hours
Depth Refinement	< 1 hours	< 1 hours	< 1.5 hours
Storage require	2.9GB	3.9GB	47MB

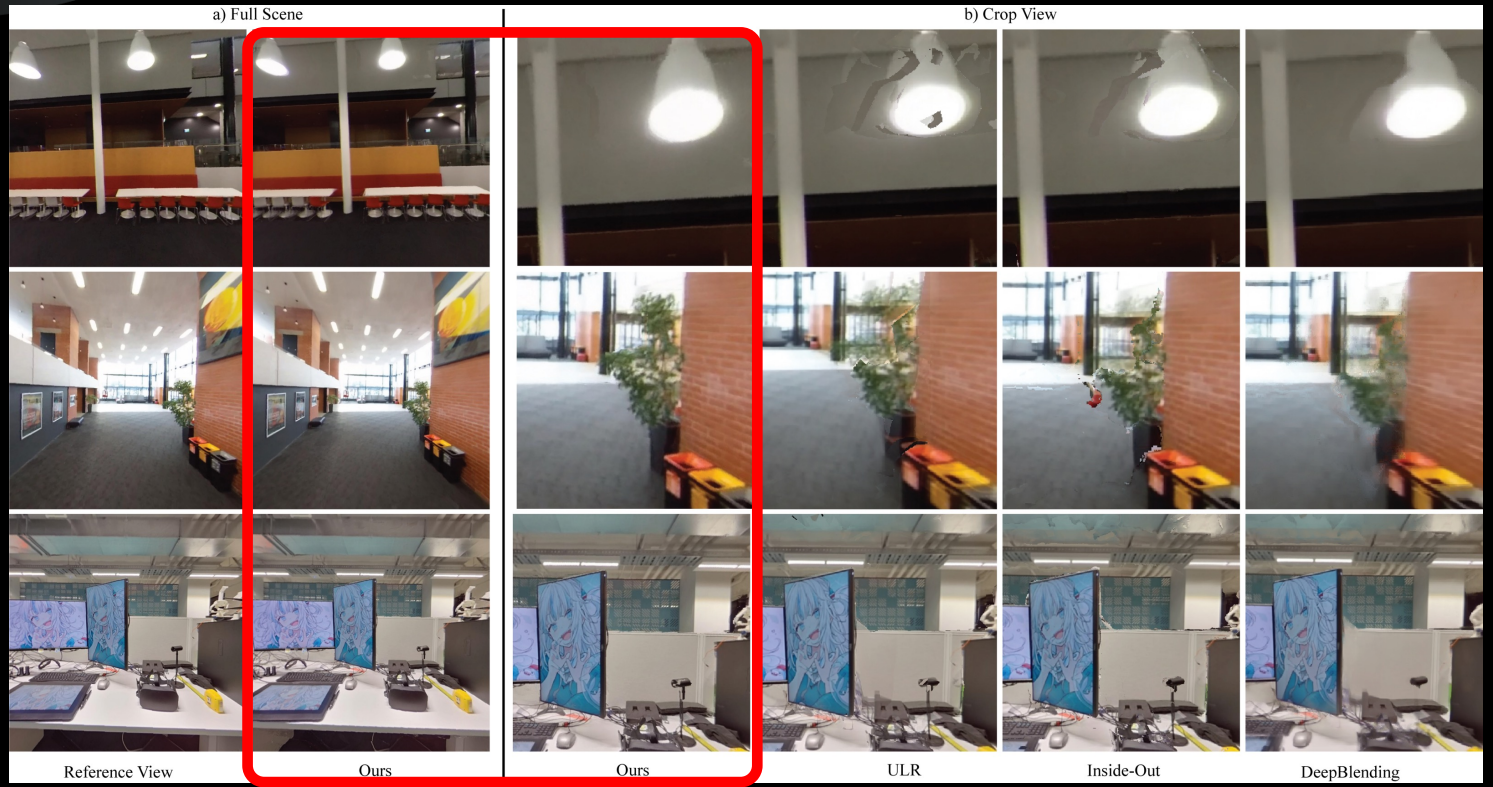
TABLE 3: The processing time of a scene of 20 input panoramas for the tested methods.

Impact of number of inputs (quality and time)

	56 inputs	33 inputs	20 inputs
Process-time	< 18 hours	< 8 hours	< 5 hours
PSNR↑	23.75	22.05	20.79
SSIM↑	0.93	0.91	0.87
LPIPS↓	0.05	0.07	0.10

TABLE 1: The impact of number of input panoramas to the process time and quality.

Result Compared to Previous Works (Indoor)



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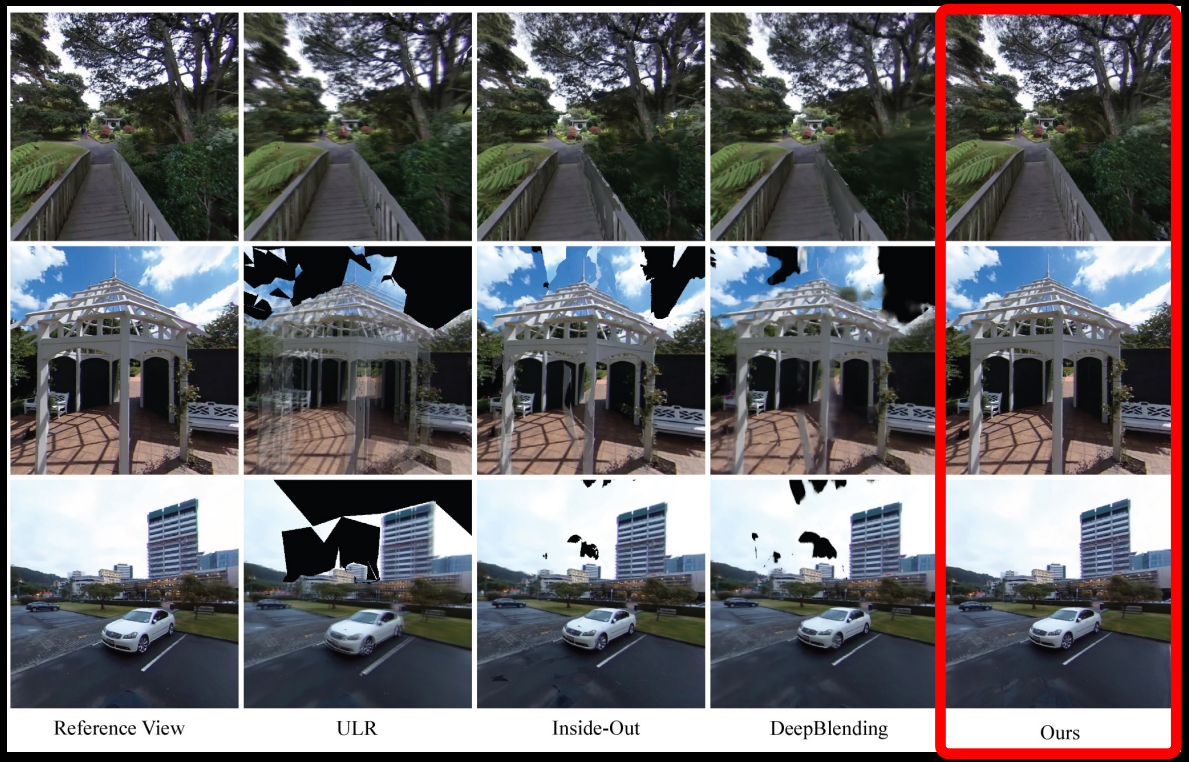
Result Compared to Previous Works (Outdoor)



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Limitation

- Overall quality can be improved with
  - Better depth estimation
  - Additional efforts for reflective and transparent surface
- Can not work with scene contains dynamic object
- User-study

Future Work

- Learning based approach
- Dynamic scene
- Evaluation with User Study

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Conclusion

- A novel pipeline that can create 6-DoF content using a single handheld consumer-grade 360° camera
- Depth estimation for for 360 panorama
- Demonstration for 6-DoF navigation in a large-scale scene

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Thank You

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