Sight & Sound Workshop, CVPR 2020, June 2020

BatVision with GCC-PHAT Features for Better Sound to Vision Predictions

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Existing Sensors have some Drawbacks

- Vision is valuable sensor but sometimes fails
- Ultrasound, Radar or LIDAR sensors are often costly, complex and provide limited information

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Approach Inspired by Nature

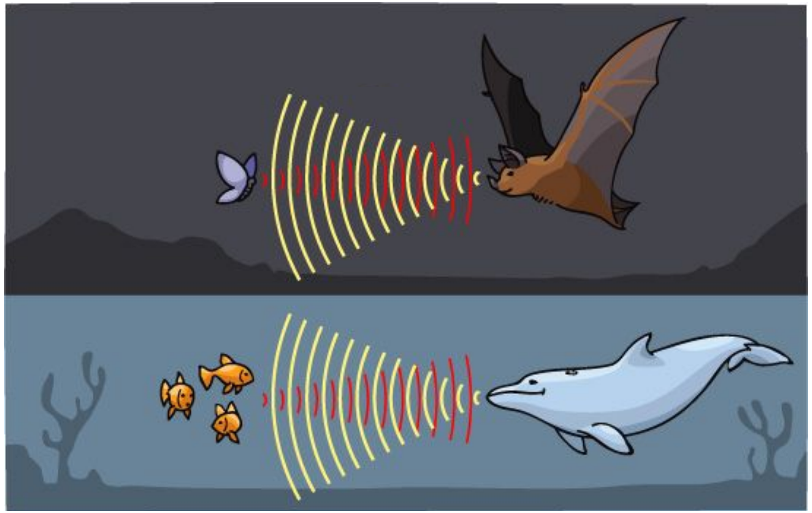
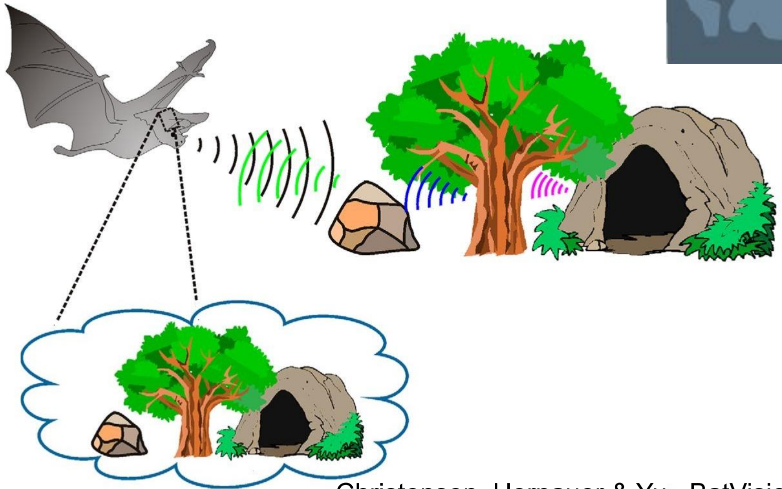
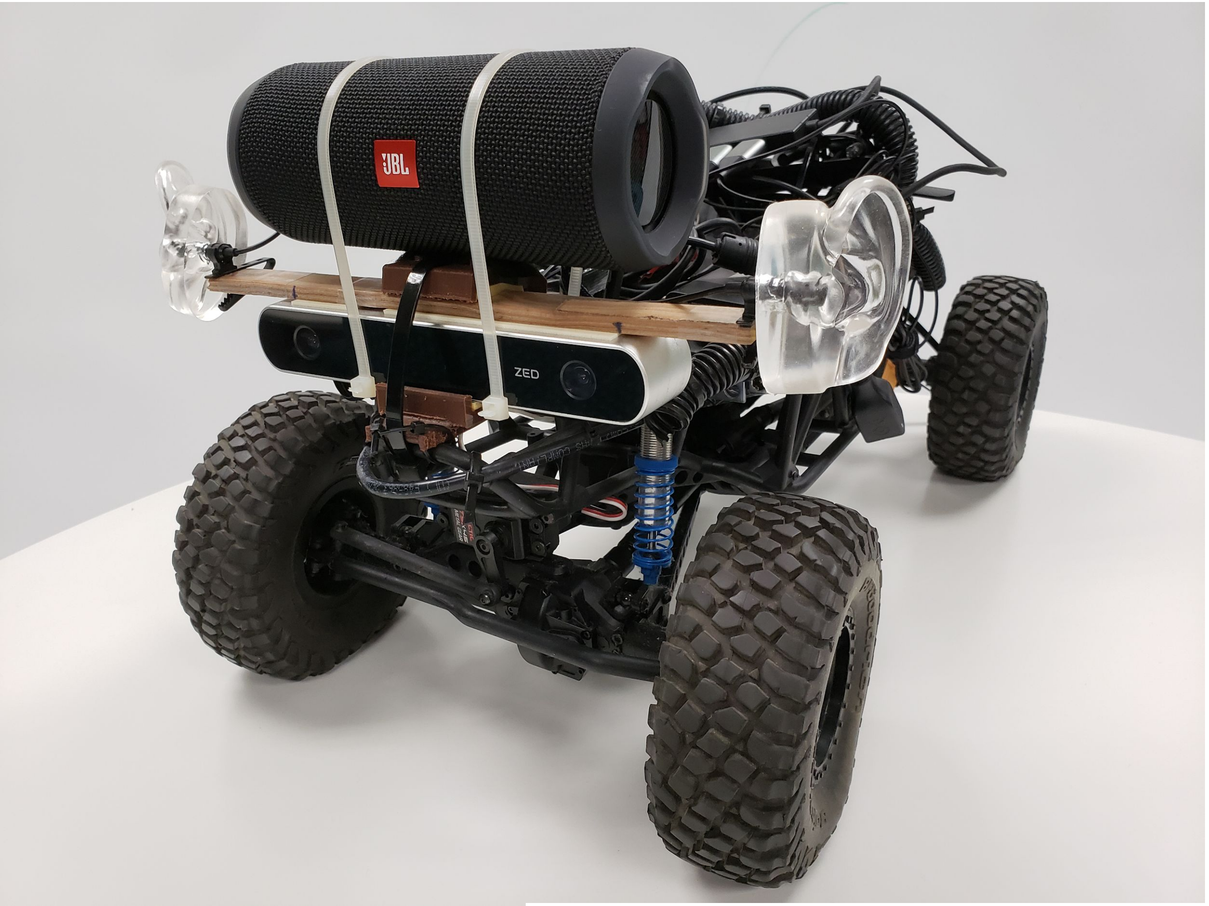


Image credit: https://askabiologist.asu.edu/echolocation



Batvision System



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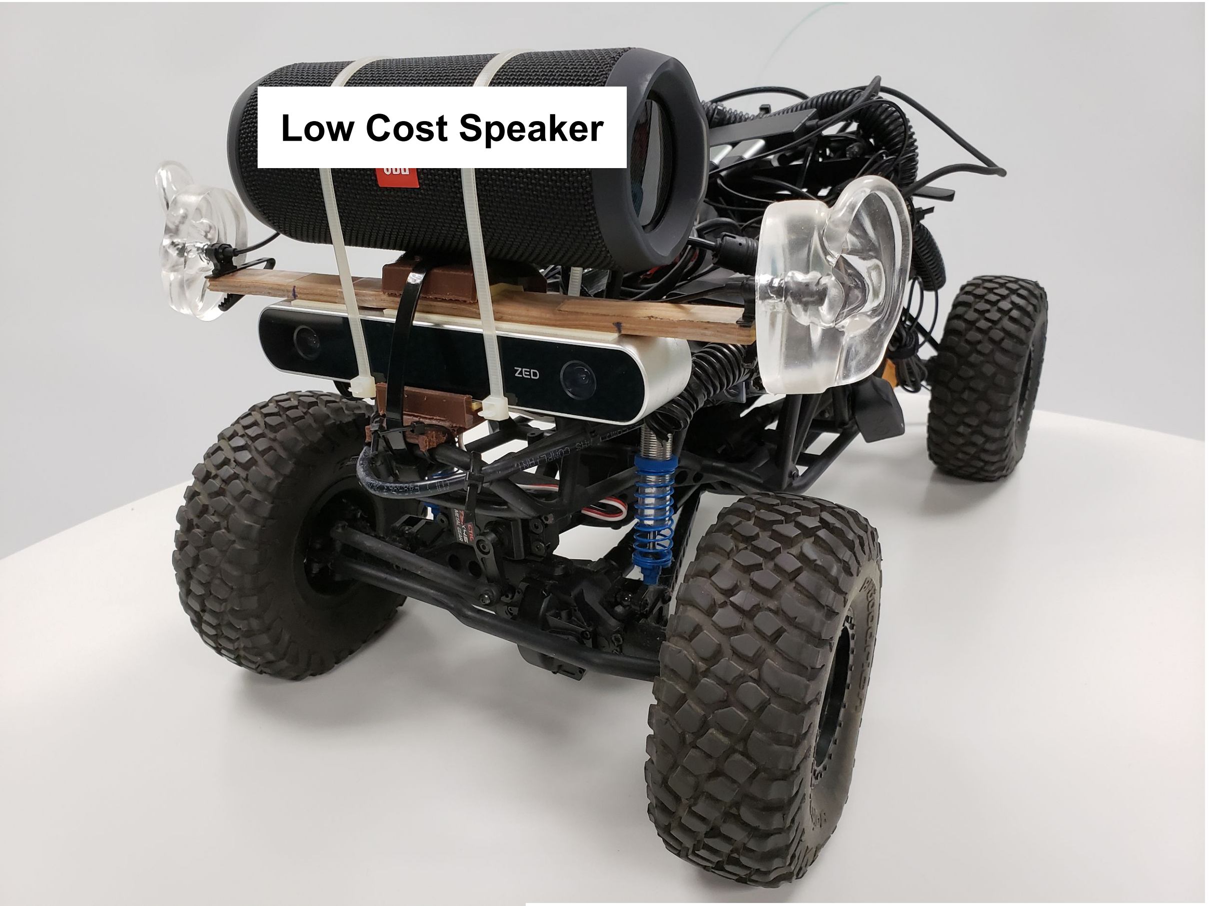
Batvision System



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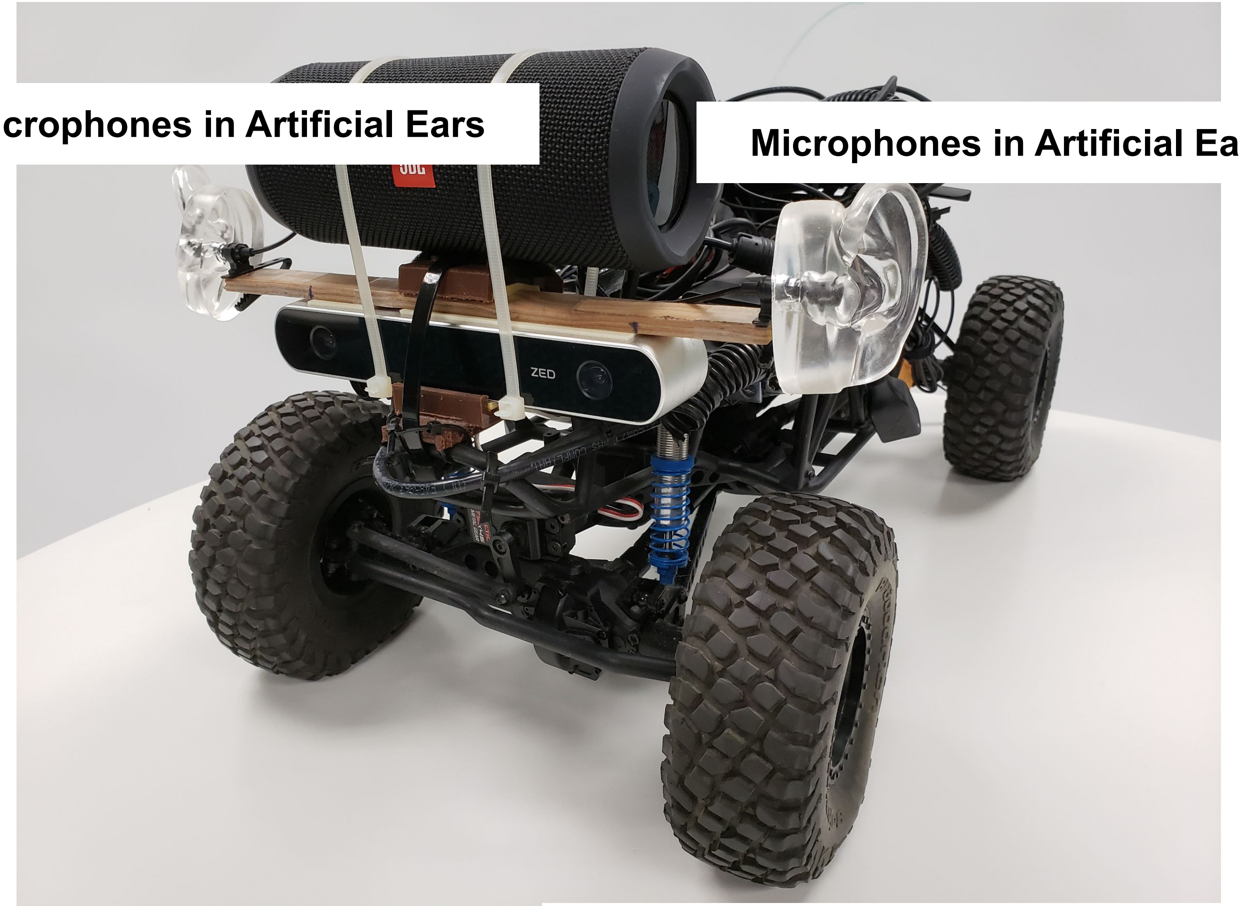

Microphones in Artificial Ears

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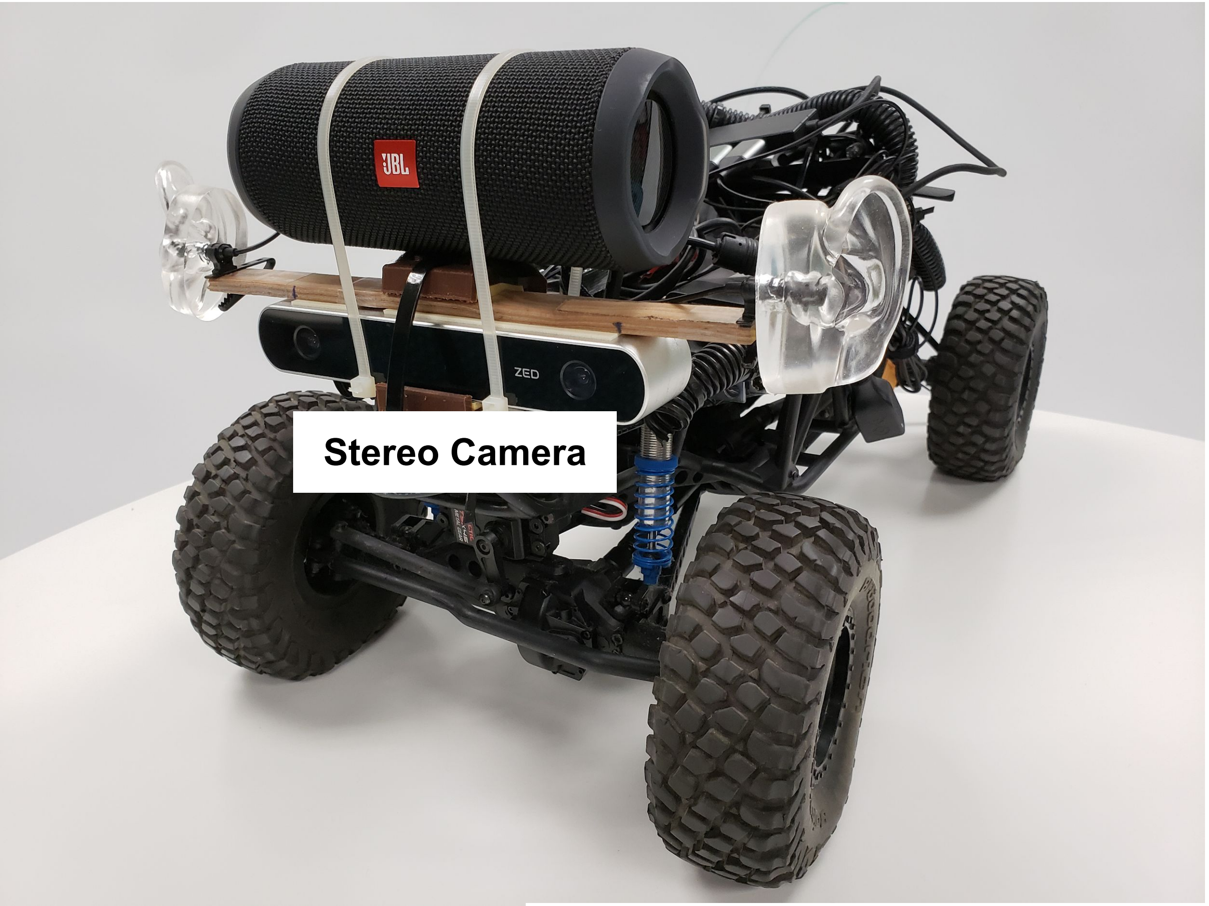
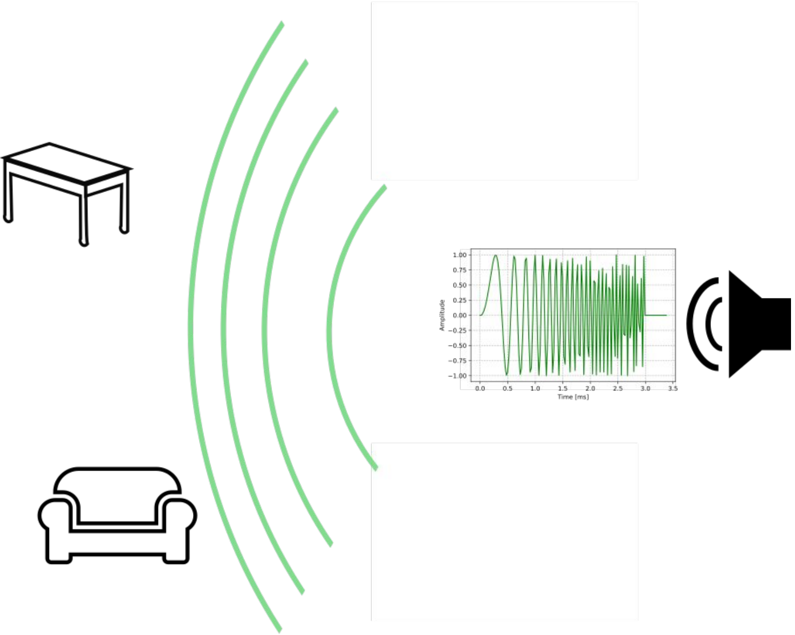
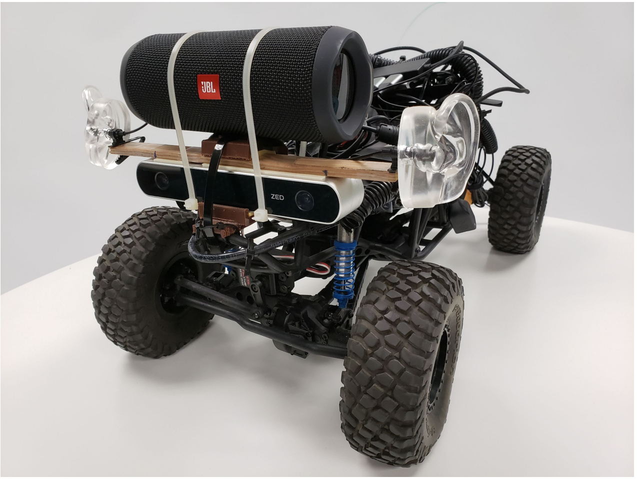
Batvision System



Stereo Camera

Batvision System

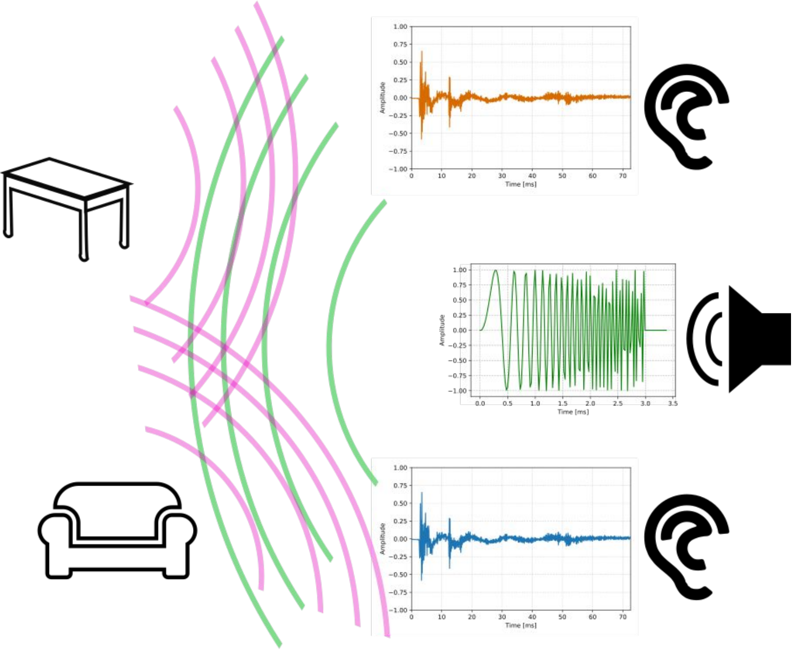


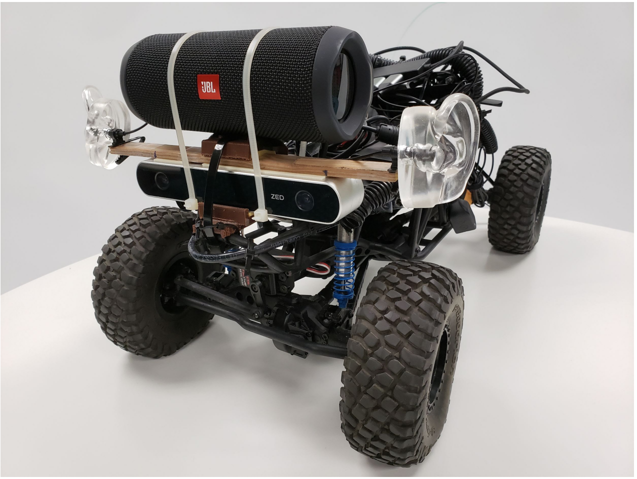


Chirp:

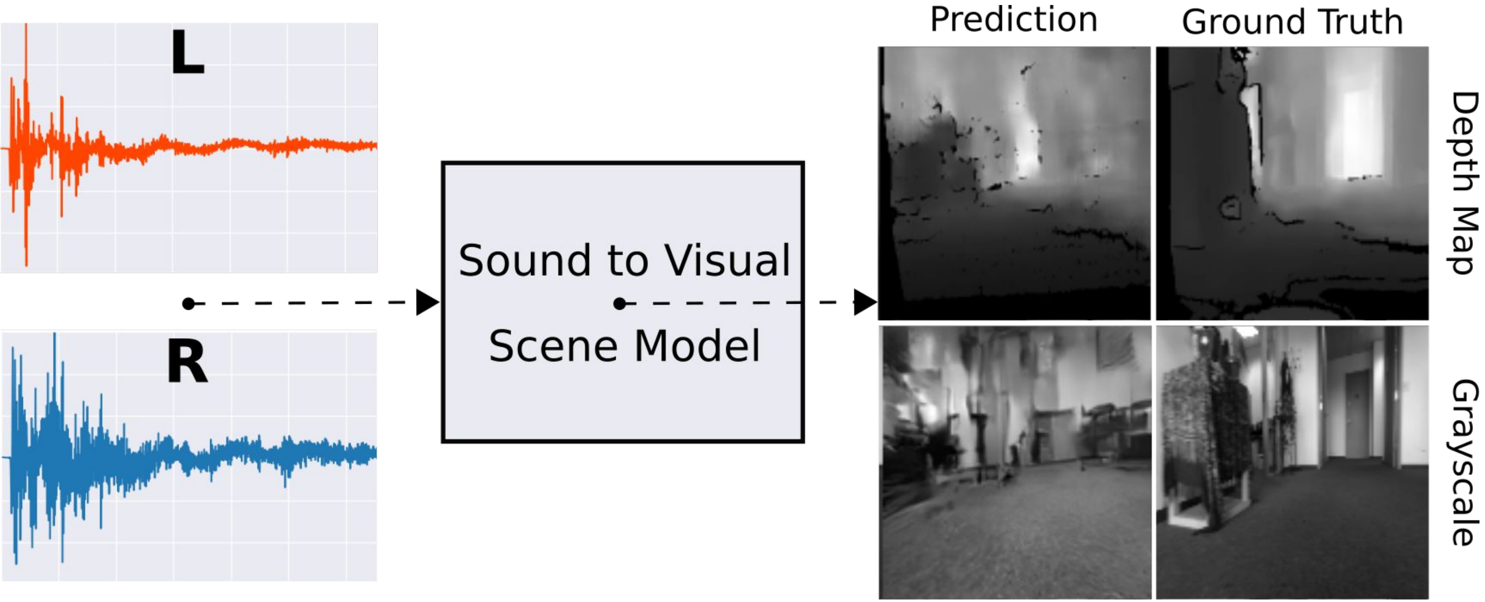
- 3 Milliseconds
- From 20hz to 20kHz

Batvision System





Neural Network Prediction of Visual Layout from Sound



Sound to Visual Scene Model

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Dataset: Binaural echo to depth

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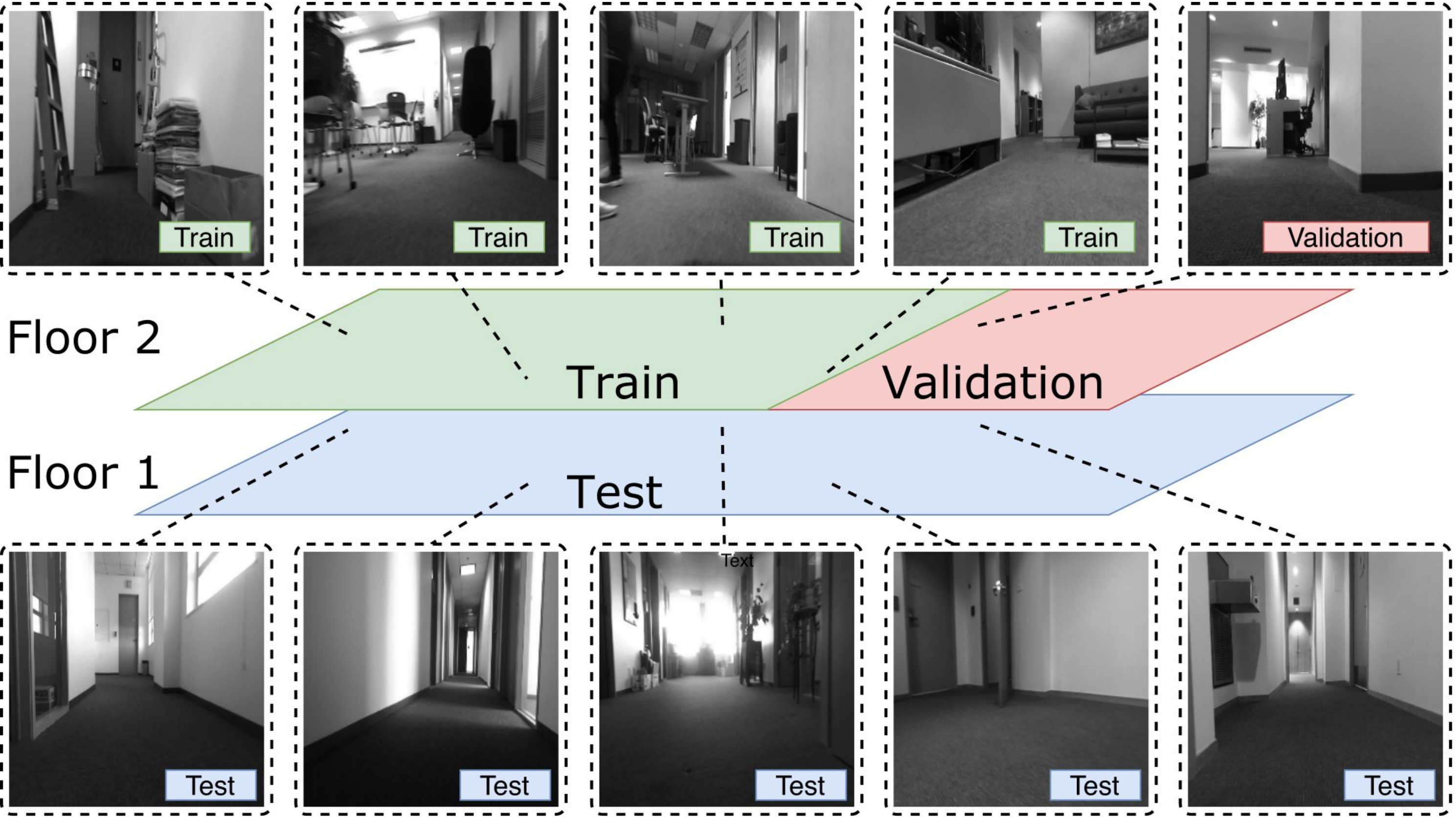
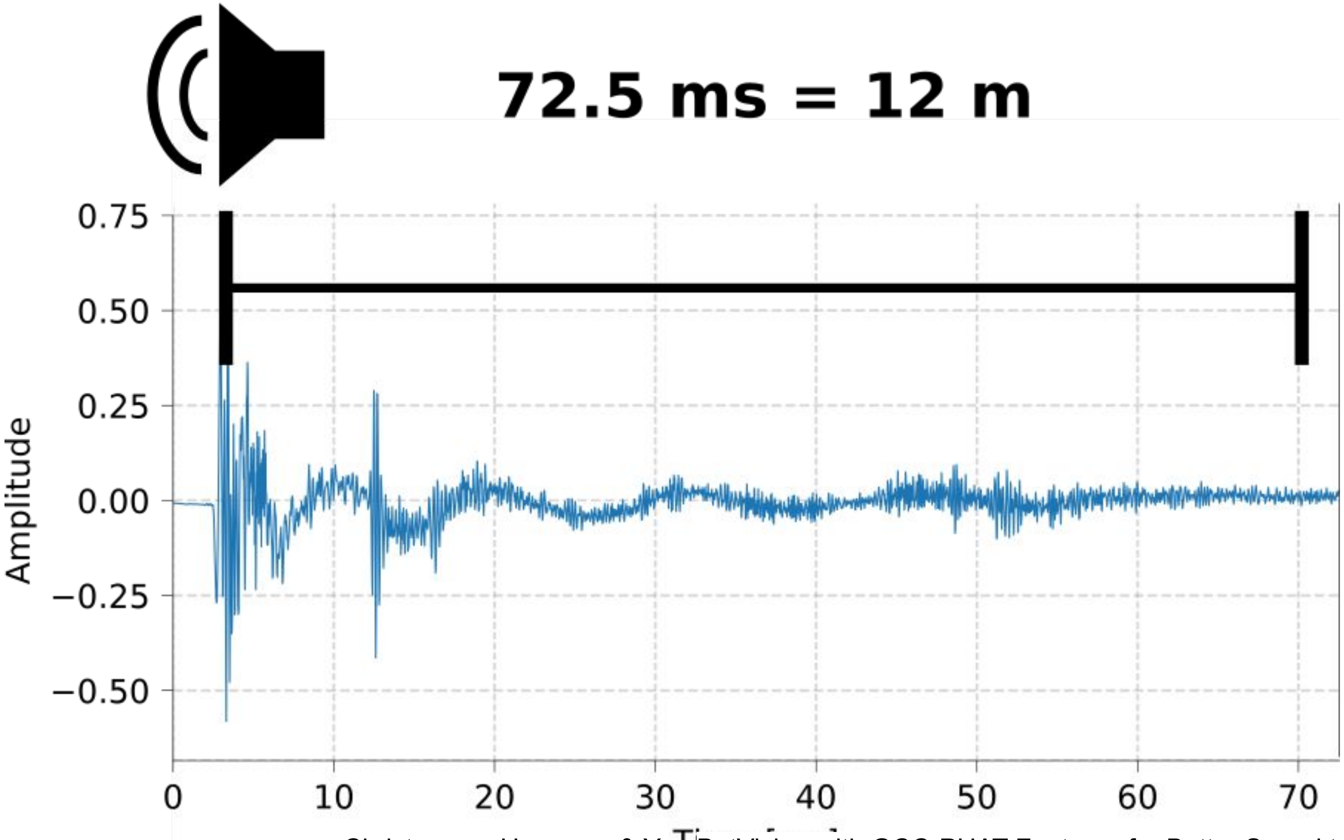
Data Collection in Office Building



Echos cut off at fixed distance



72.5 ms = 12 m

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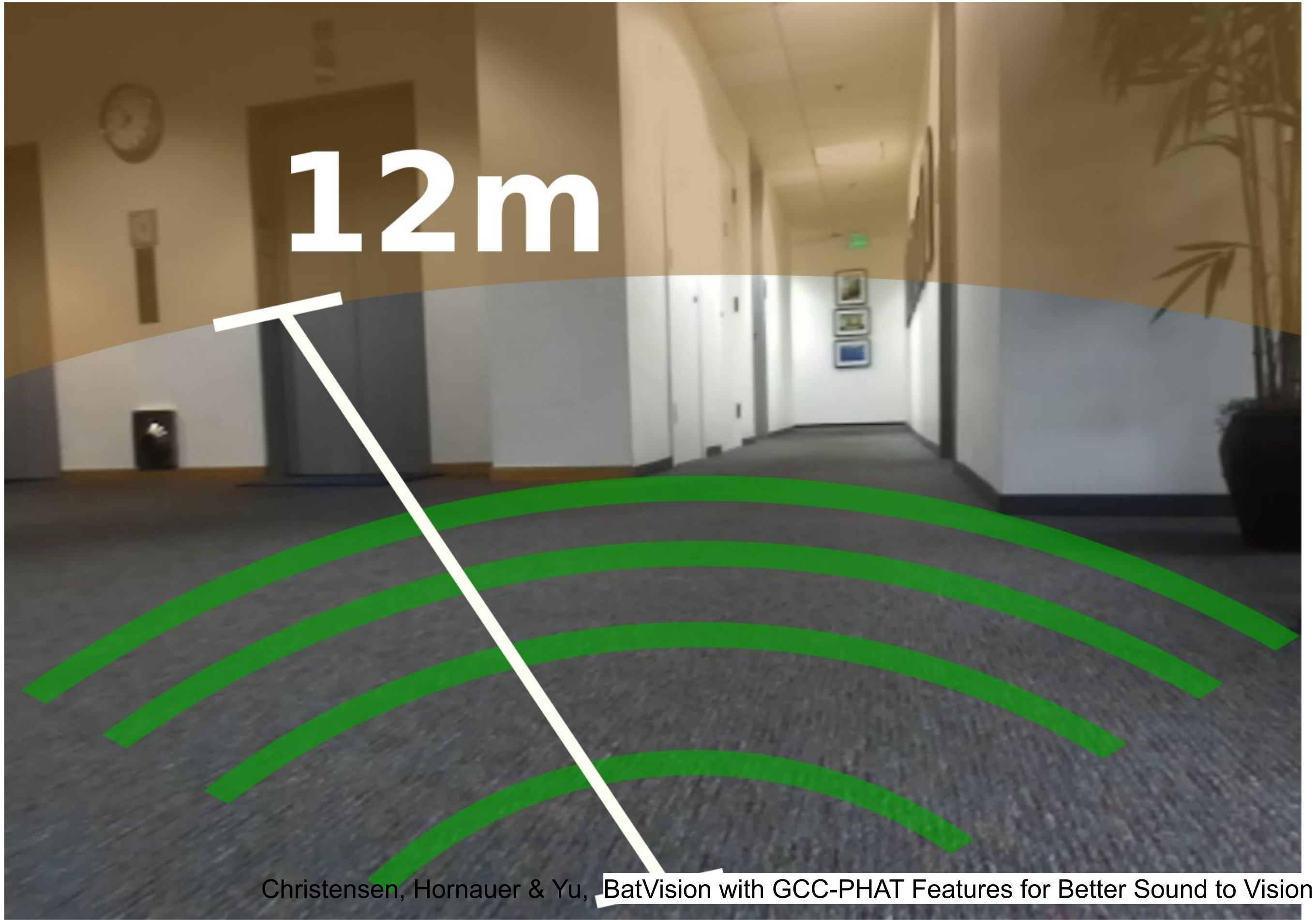
Structure Beyond can not be Directly Observed



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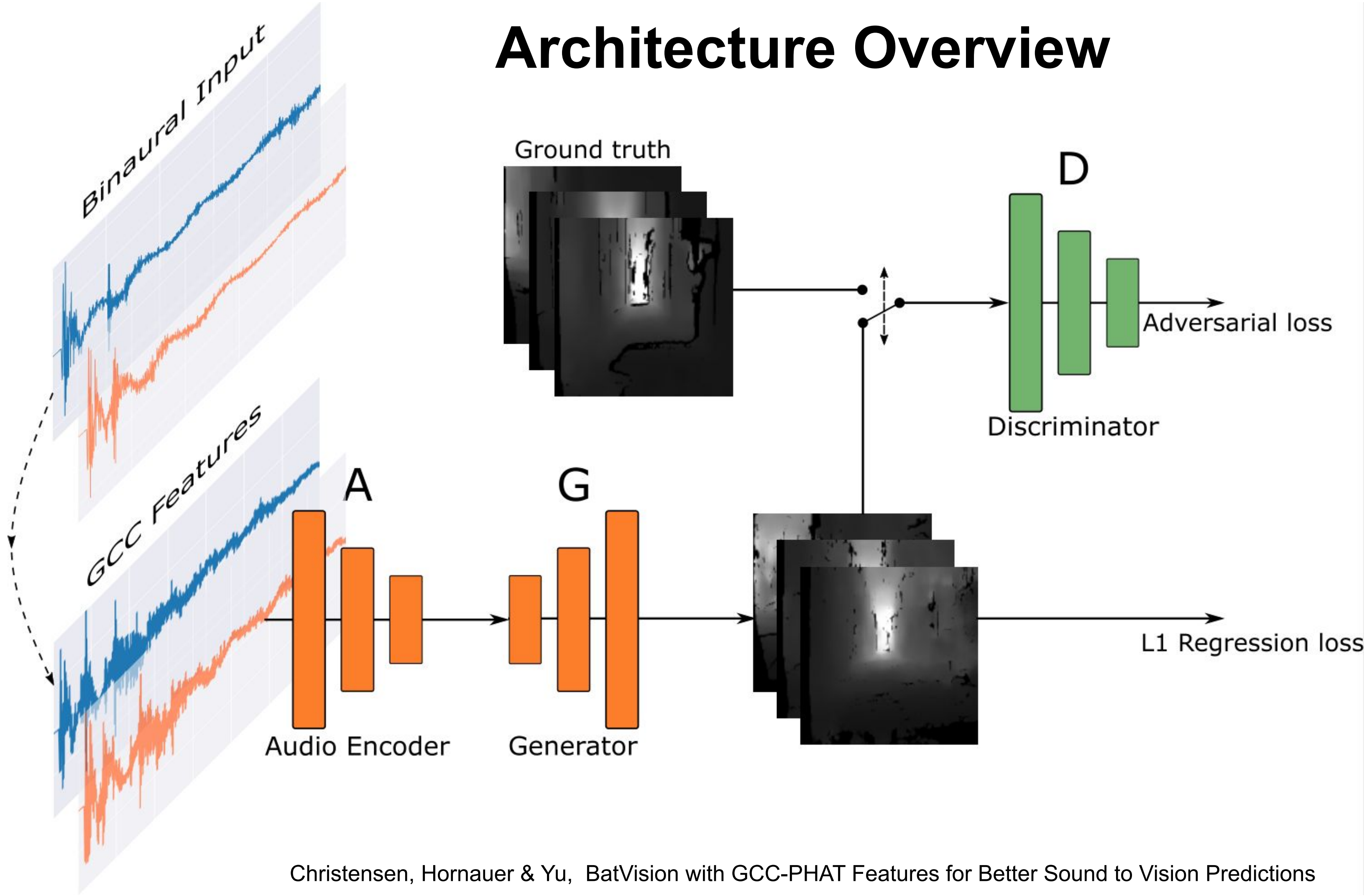
Architecture Overview



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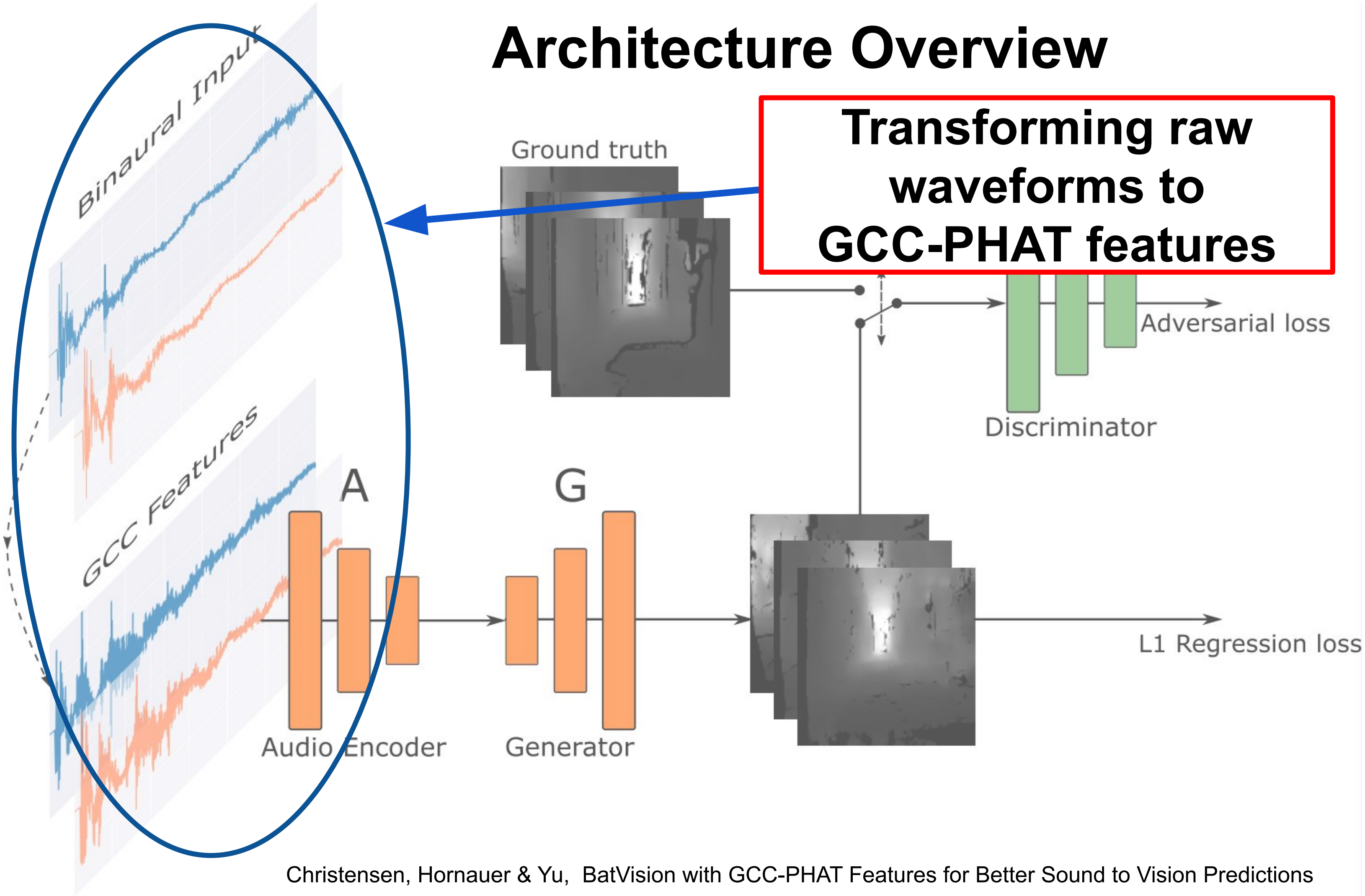

Transforming raw waveforms to GCC-PHAT features

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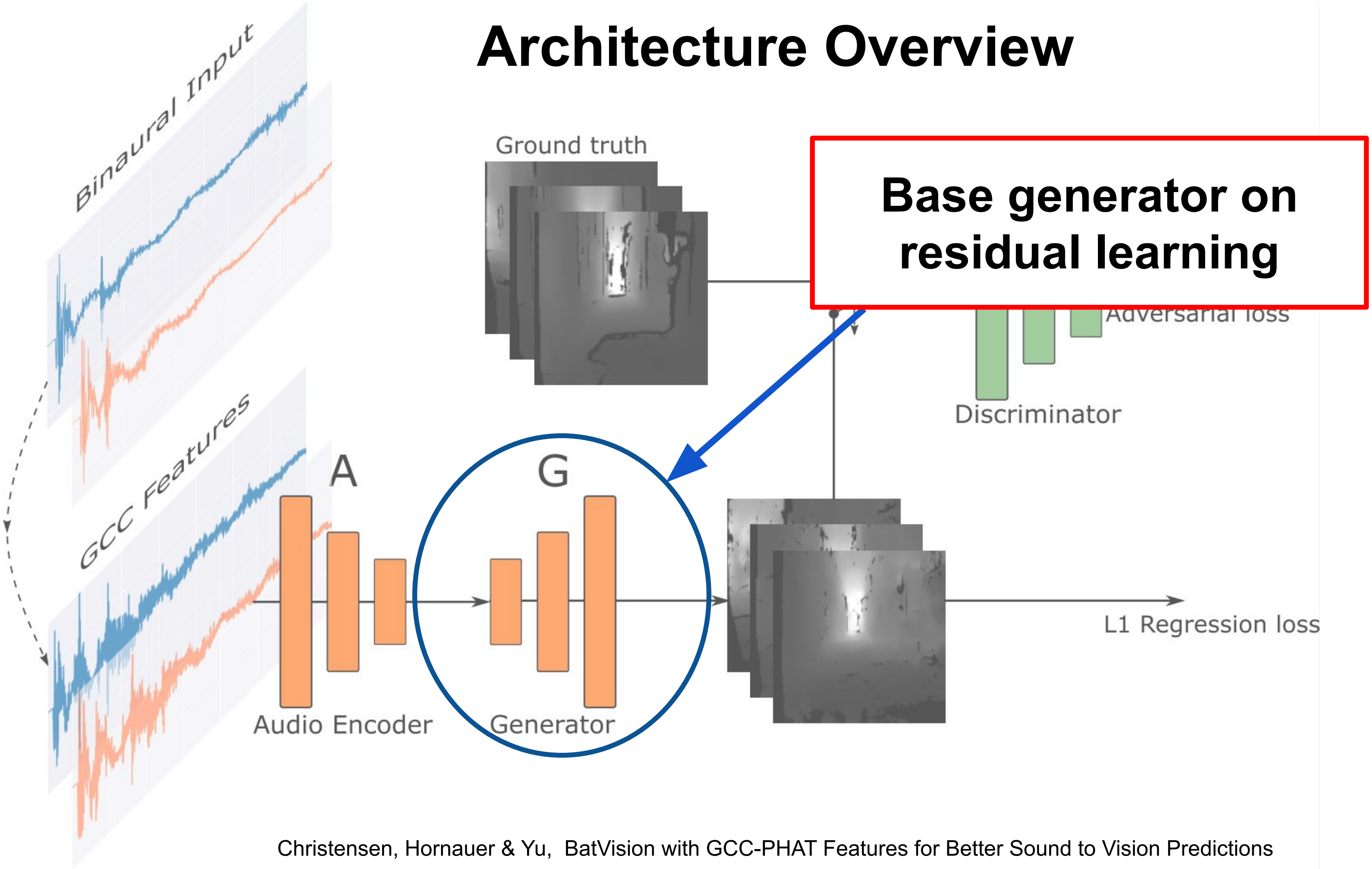
Architecture Overview



Base generator on residual learning

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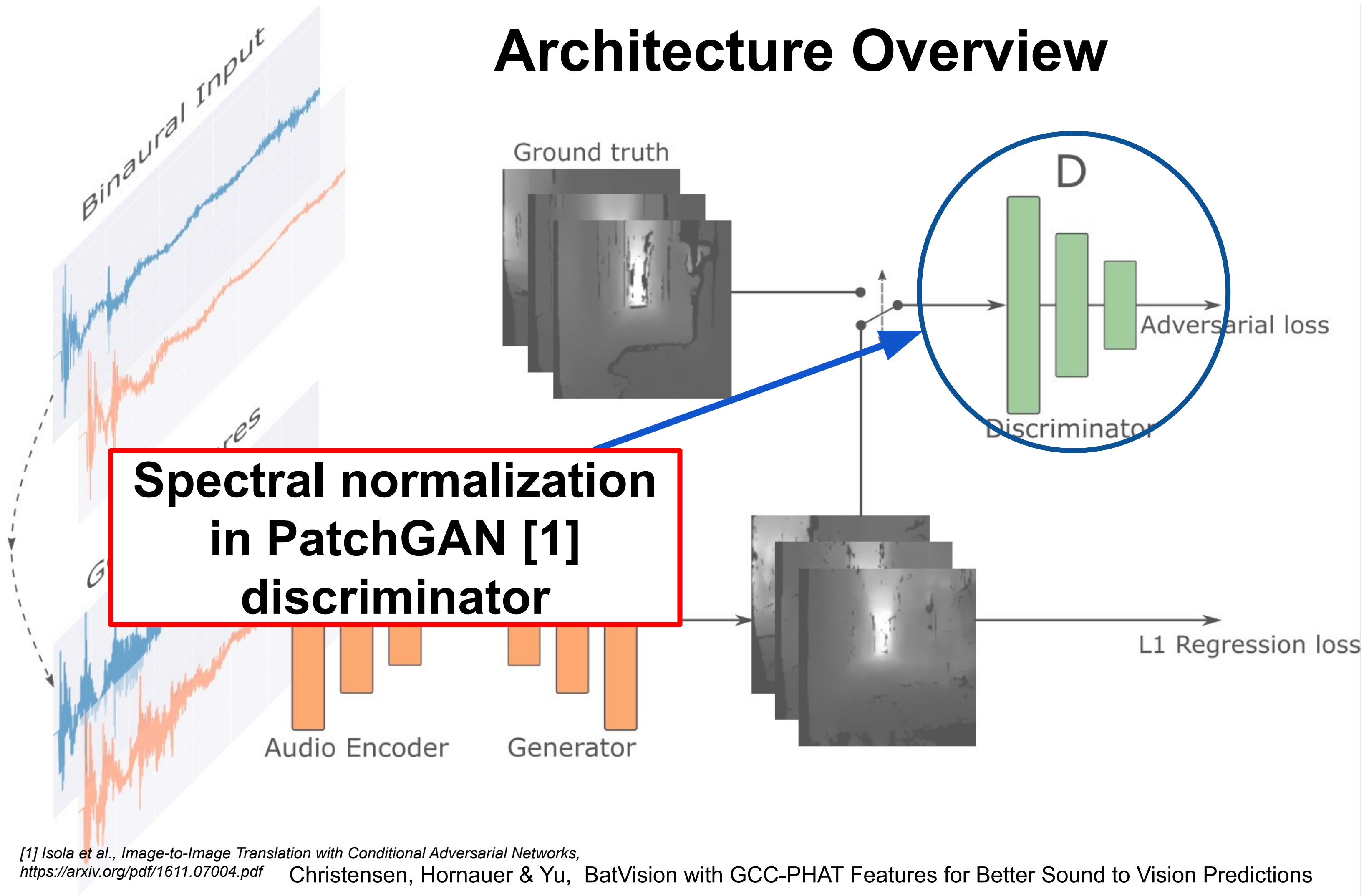
Architecture Overview

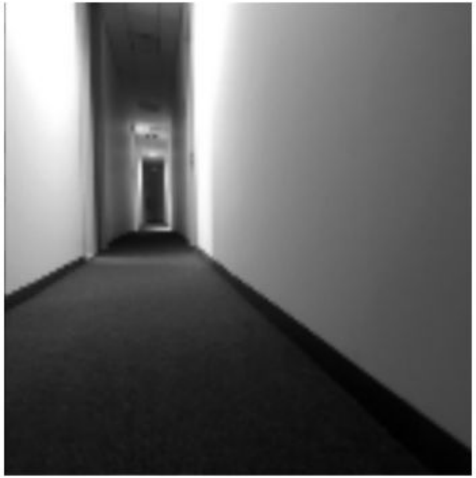


Spectral normalization in PatchGAN [1] discriminator

[1] *Isola et al., Image-to-Image Translation with Conditional Adversarial Networks, https://arxiv.org/pdf/1611.07004.pdf*

Results: Depth map prediction

Generated from a single binaural echo only!



Grayscale image
from camera

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Results: Depth map prediction

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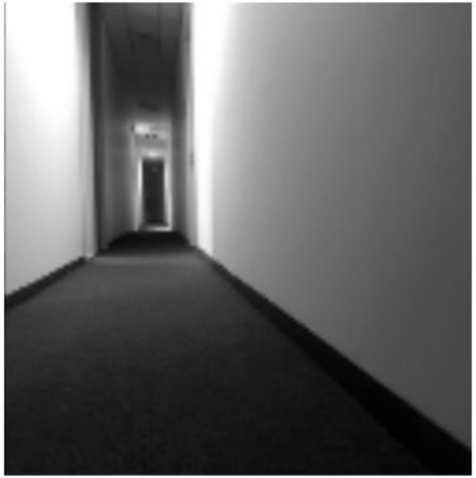

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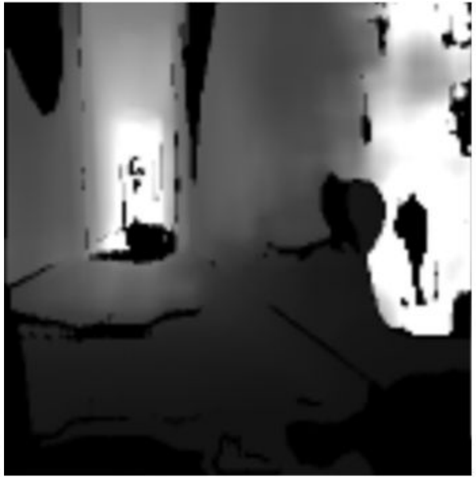

Depth map
from stereo camera

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Results: Depth map prediction

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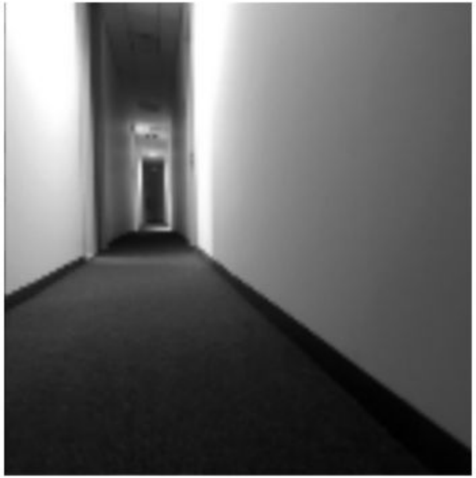

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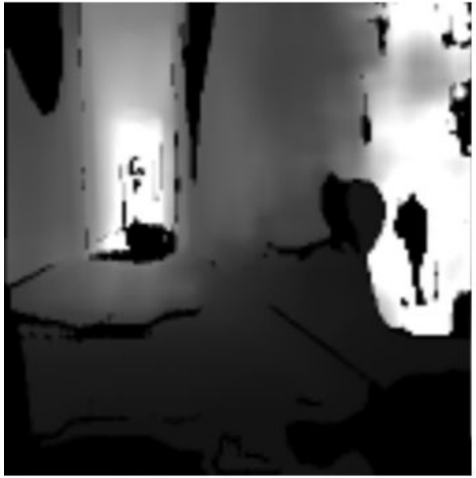
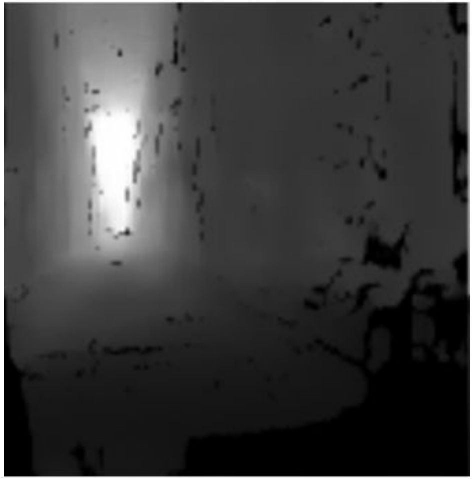


Depth map
from stereo camera

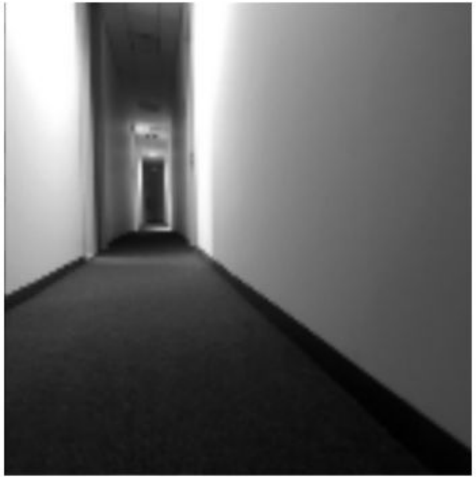


**Predicted depth map
from BatVision [1]**

[1] Christensen, Hornauer, Yu. BatVision: Learning to See 3D Spatial Layout with Two Ears. In ICRA 2020.

Results: Depth map prediction

Generated from a single binaural echo only!



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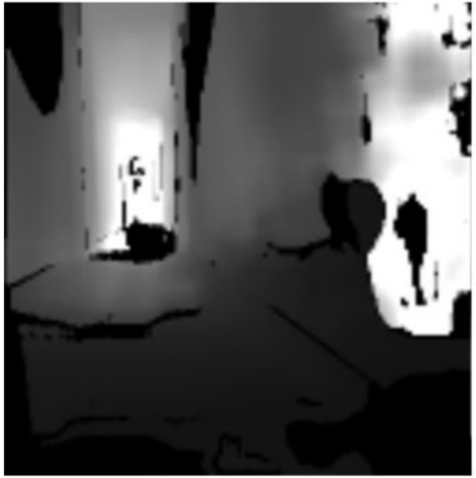

Depth map
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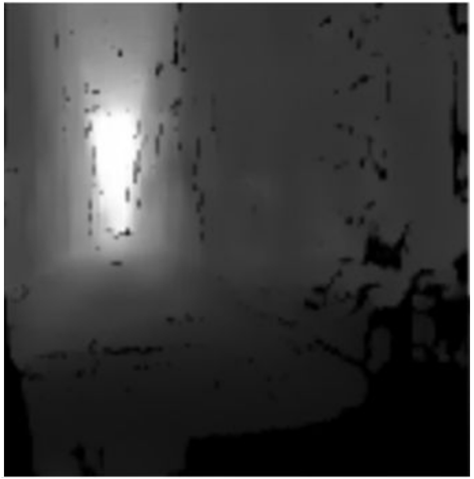
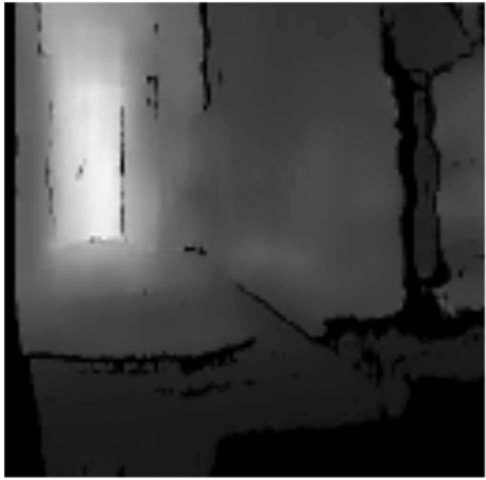


**Predicted depth map
from BatVision [1]**



**Predicted depth map
from our improved
BatVision model**

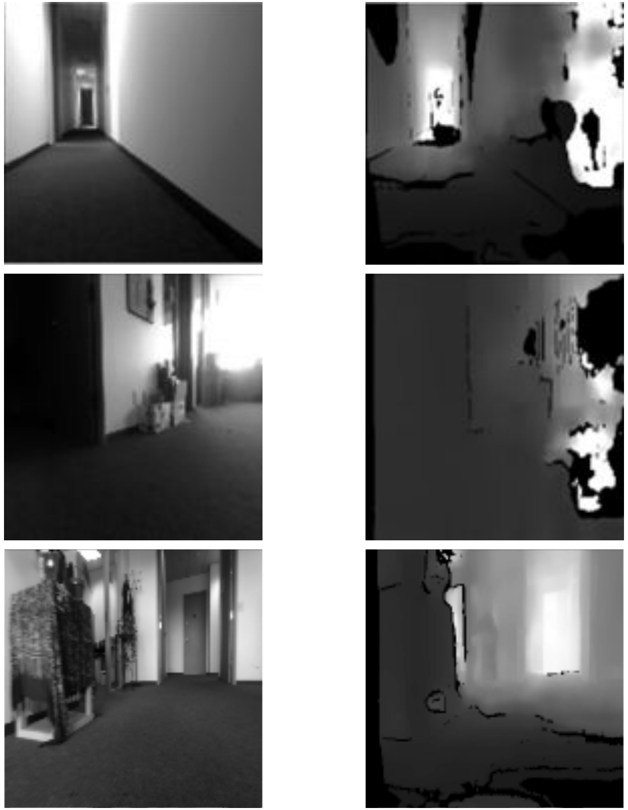
[1] Christensen, Hornauer, Yu. BatVision: Learning to See 3D Spatial Layout with Two Ears. In ICRA 2020.

Results: Improved predictions and less noise

Scene

Christensen, Hornauer & Yu, BatVision with GCC-PHAT Features for Better Sound to Vision Predictions

Results: Improved predictions and less noise



Scene **Stereo GT**

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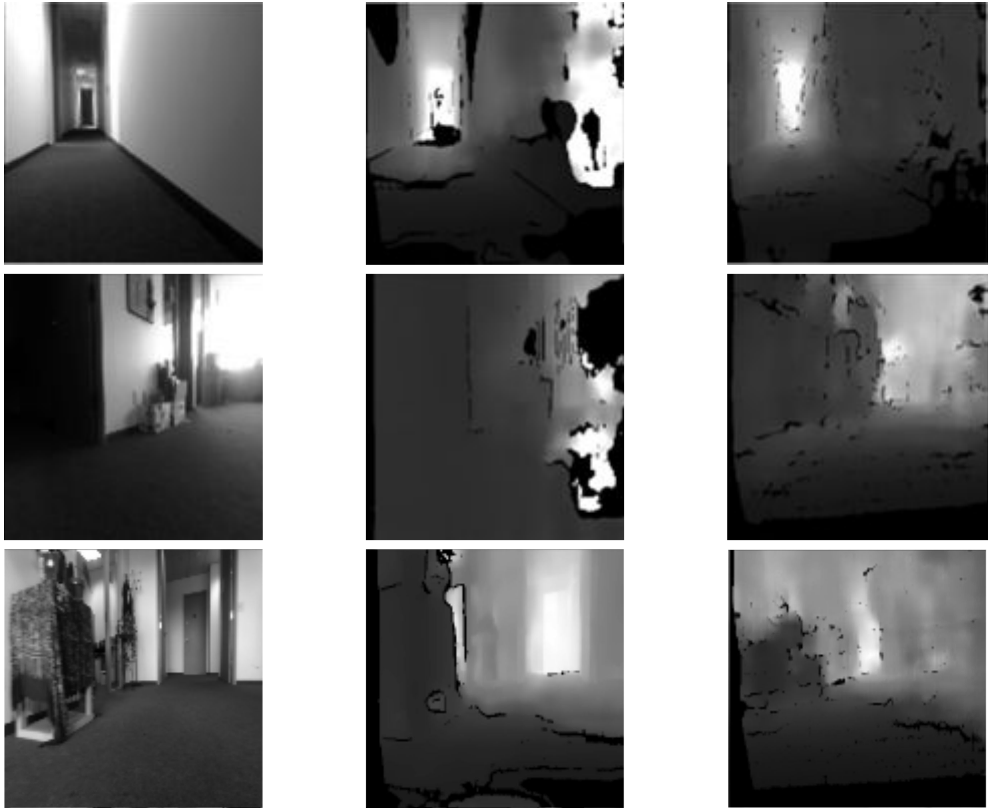
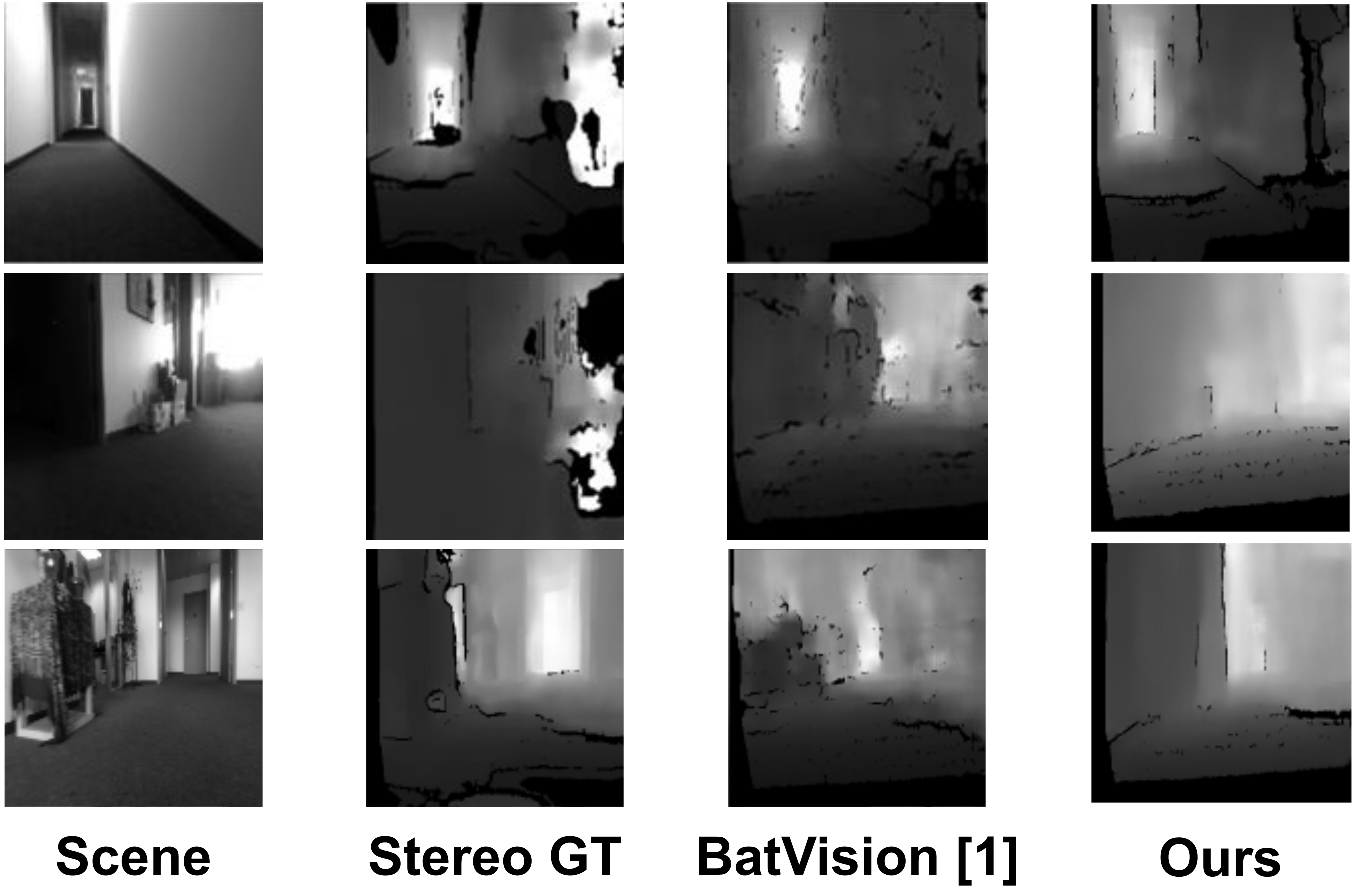
Results: Improved predictions and less noise



Scene **Stereo GT** **BatVision [1]**

[1] Christensen, Hornauer, Yu. BatVision: Learning to See 3D Spatial Layout with Two Ears. In ICRA 2020.

Results: Improved predictions and less noise



Scene

Stereo GT

BatVision [1]

Ours

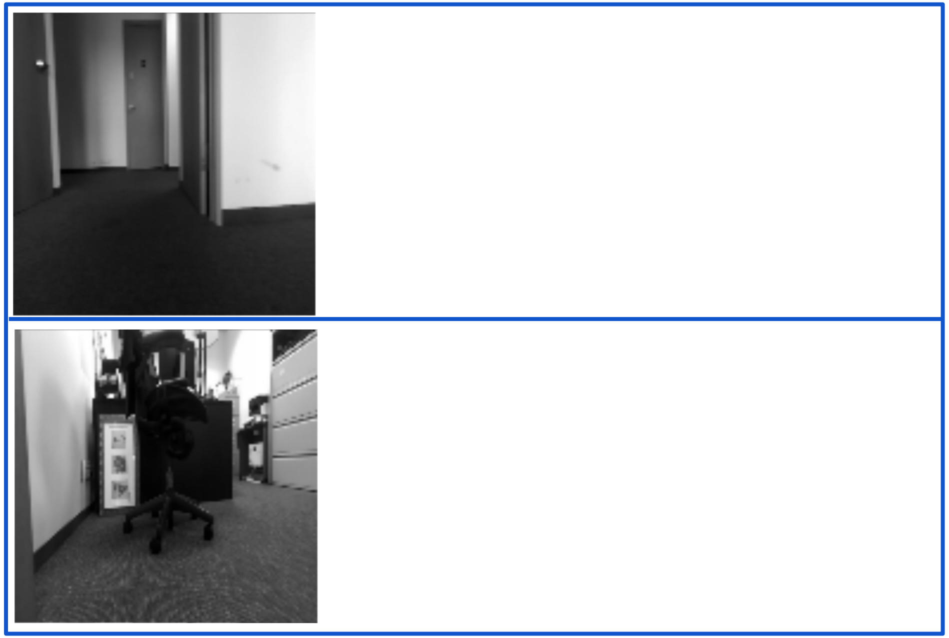
[1] Christensen, Hornauer, Yu. BatVision: Learning to See 3D Spatial Layout with Two Ears. In ICRA 2020.

Results: Grayscale layout

No depth used for training!

Plausible layout of free space / obstacles

Scene



Scene

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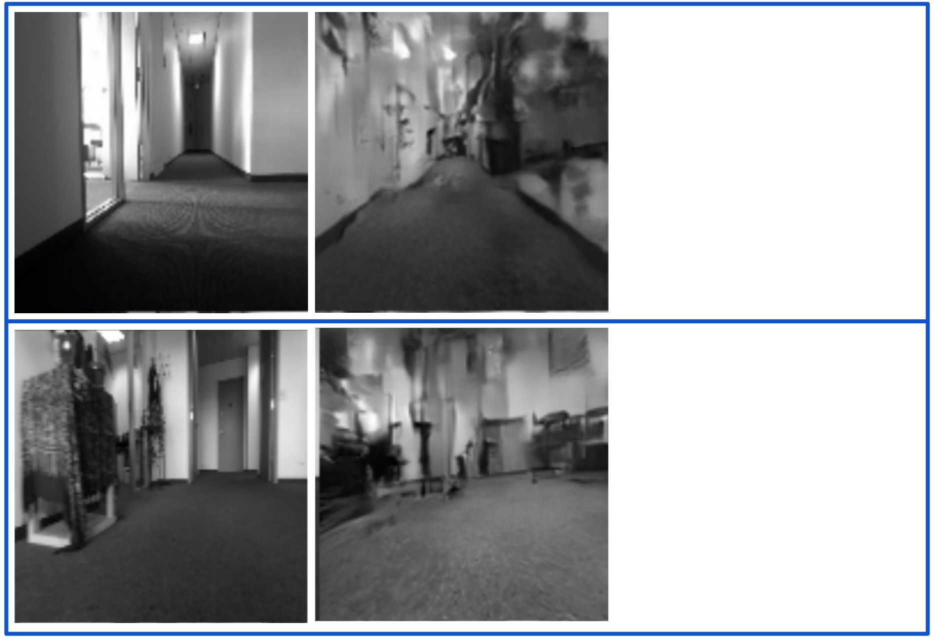
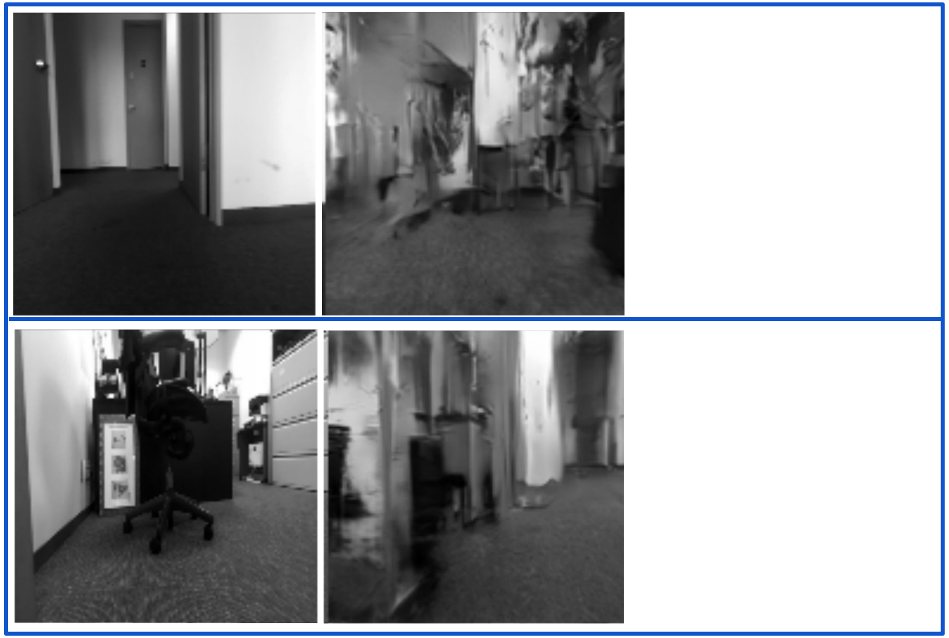


Scene BatVision [1]



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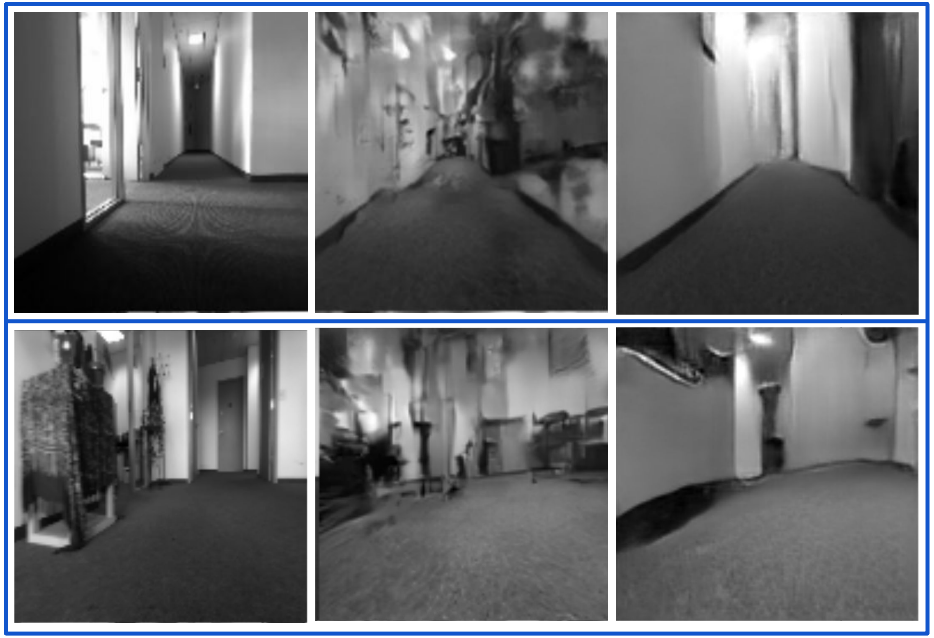
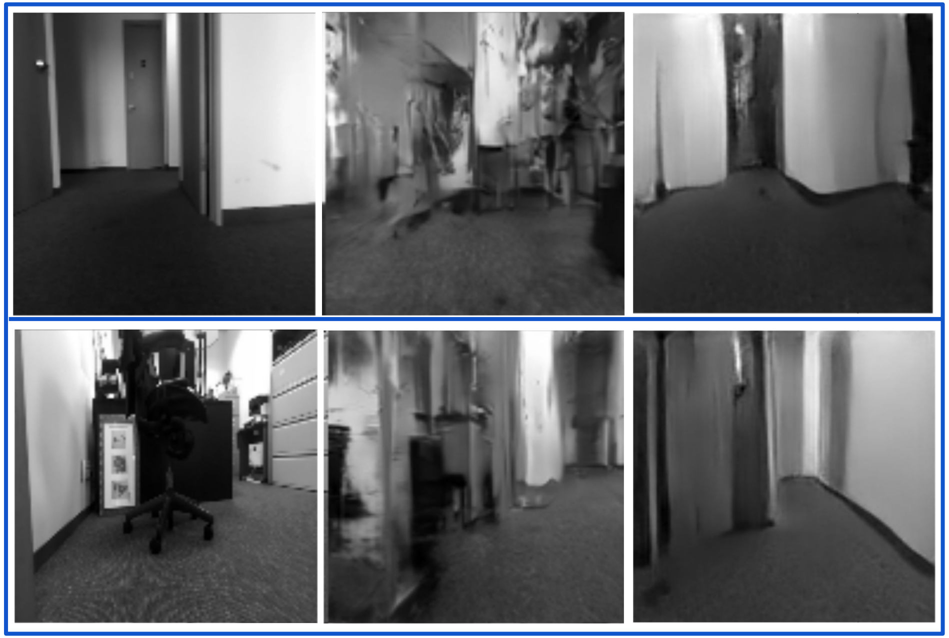


Scene **BatVision [1]** ***Ours***



Scene **BatVision [1]** ***Ours***

[1] Christensen, Hornauer, Yu. BatVision: Learning to See 3D Spatial Layout with Two Ears. In ICRA 2020.

Conclusion

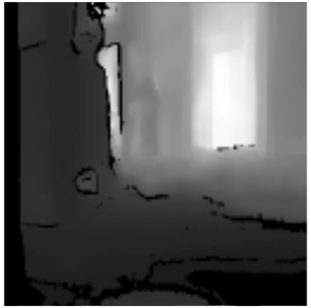
➜ Improving sound-to-**vision**

➜ Increasing perceptual quality and quantitative measures

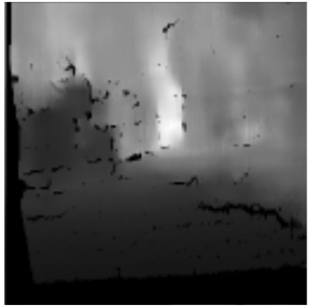
➜ More stable training process

➜ Less noisy depth and layout predictions

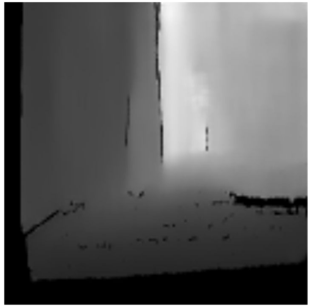
Stereo depth



BatVision

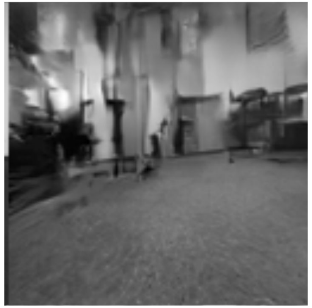


Our improved BatVision



Grayscale image

BatVision layout



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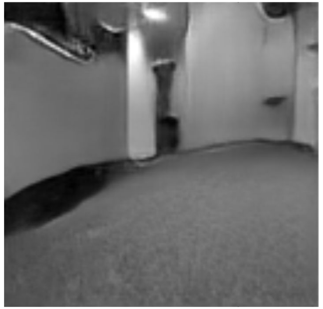

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