

RGB-D Keyframe Fusion

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Outline

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Objective

- Fusing low resolution RGB-D frames to obtain a high resolution RGB-D keyframe using depth and color fusion



LR Input frame



Fused SR frame

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Overview

- Creating a super-resolution keyframe
- Keyframe fusion using:
 - Depth Fusion
 - Color Fusion



Super-Resolution Keyframe

- Upsample the low resolution input frame with a given scaling factor
- Create a depth map
- Fuse 20 neighboring frames into a common keyframe representation of higher resolution



Depth Fusion - First Approach

- Project the low res. 2D input point to 3D coordinates
- Transform the 3D points to SR keyframe using its relative pose
- Project the points back to 2D space updating all four neighbors for sub pixel precision
- Compute the input depth weight



Depth Fusion - Ray Version

- Iterate over the pixels of keyframe
- Compute ray between optical center and pixel in keyframe
- Transformation to coordinate system of new frame
- Get the search space by projecting 3D ray to 2D image plane
- Transform pixels in search space to coordinate system of the keyframe
 - check if they match (position, colors)
 - update accordingly

- Update the depth value and depth weight using:

$$\mathcal{Z}^*(\mathbf{x}^*) := \frac{\mathcal{W}^*(\mathbf{x}^*)\mathcal{Z}^*(\mathbf{x}^*) + w(\mathcal{Z}_i(\mathbf{x}))Z}{\mathcal{W}^*(\mathbf{x}^*) + w(\mathcal{Z}_i(\mathbf{x}))}$$

$$\mathcal{W}^*(\mathbf{x}^*) := \mathcal{W}^*(\mathbf{x}^*) + w(\mathcal{Z}_i(\mathbf{x}))$$

where:

\mathcal{Z}^* : fused depth map

\mathcal{W}^* : fused weights

\mathcal{Z}_i : input depth map

Z : transformed depth values

w : weighting function, defined as $w(d) = \frac{fb}{\sigma_d} d^{-2}$



Color Fusion

- Preprocessing: unsharp masking to deblur the image, uses Gaussian convolution
- Take mapped pixels after depth fusion to update color values accordingly
- Color update: look up the color of all three channels in the deblurred input image



Color Fusion

- Color updates work similarly to the updates of depth values
- The weights for color fusion incorporate a blurriness measure:

$$w_i^c = B_i w_z(Z_i(x))$$

B_i = Normalized blurriness measure of the color image

Color Fusion - Weighted Median

- set of color observations and weights for a pixel x :

$$\mathcal{O}_x = \{(\mathbf{c}_i, w_i^c)\}$$

- find the weighted median for each color channel separately

$$\mathbf{C}^*(x) = \operatorname{argmin}_{\mathbf{c}} \sum_{(\mathbf{c}_i, w_i^c) \in (\mathcal{O}_x)} w_i^c \|\mathbf{c} - \mathbf{c}_i\|$$

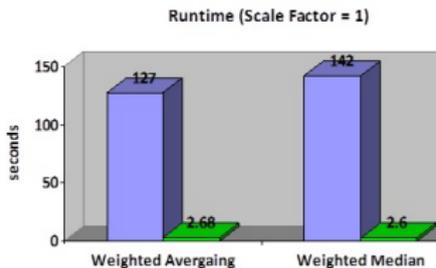
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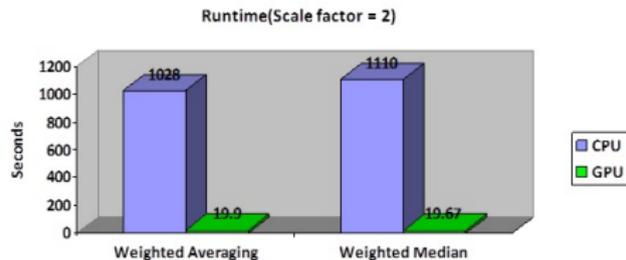
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Results



Perf. for Scale factor 1



Perf. for Scale factor 2

Bibliography I

- [Crete et al.,] Crete, F., Dolmiere, T., Ladret, P., and Nicolas, M.
The blur effect: perception and estimation with a new no-reference perceptual blur metric.
volume 6492, pages 649201–649201–11.
- [Maier et al., 2015] Maier, R., Stueckler, J., and Cremers, D. (2015).
Super-resolution keyframe fusion for 3d modeling with high-quality textures.
In *International Conference on 3D Vision (3DV)*.
- [Meilland et al., 2013] Meilland, M., Comport, A., et al. (2013).
Super-resolution 3d tracking and mapping.
In *Robotics and Automation (ICRA), 2013 IEEE International Conference on*, pages 5717–5723. IEEE.
- [Meilland et al., 2012] Meilland, M., Comport, A., and Pôle, S. (2012).
Simultaneous super-resolution, tracking and mapping.
Technical report, CNRS-I3S/UNS, Sophia-Antipolis, France, Research Report RR-2012-05.