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Photometric Visual Servoing Through Sobel-Based Image Gradient Utilization

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INTRODUCTION & AIM

Direct photometric visual servoing (PVS) has proved to be an effective method for controlling a robot's motions by utilizing pure luminance intensities rather than classical geometric features. However, these methods are sensitive to illumination changes and partial occlusions. To overcome this, we develop a new control law based on a Sobel filter to enhance the precision of image information under changing lighting conditions by extracting image gradients.

METHOD

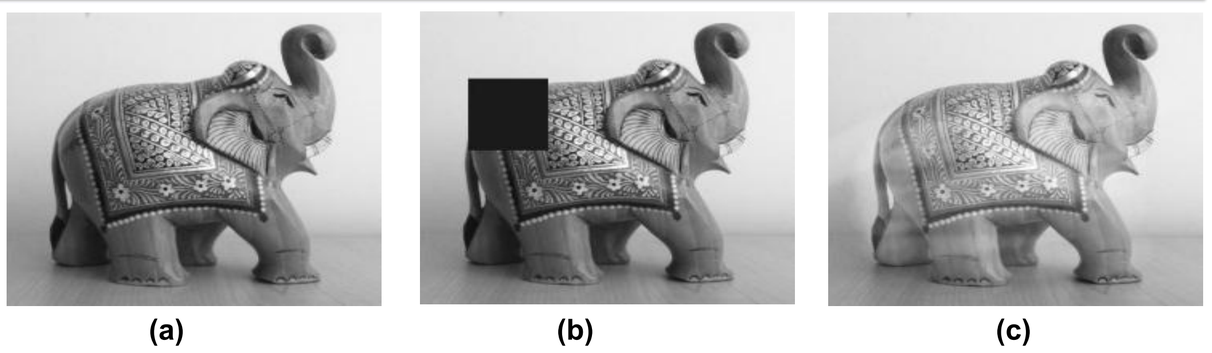
- Instead of luminance, we proposed using the gradient magnitude as visual features for the visual servoing task:

$$\boldsymbol{G} = \sqrt{\boldsymbol{G_x^2} + \boldsymbol{G_y^2}}$$

- The interaction matrix $\boldsymbol{L_{sobel}}$ was redefined using partial derivatives of linking the image gradients to robot motion.
- A control law was implemented to minimize the error $\boldsymbol{e_s(t)} = \boldsymbol{G(t)} - \boldsymbol{G^*}$ between current and desired visual features:

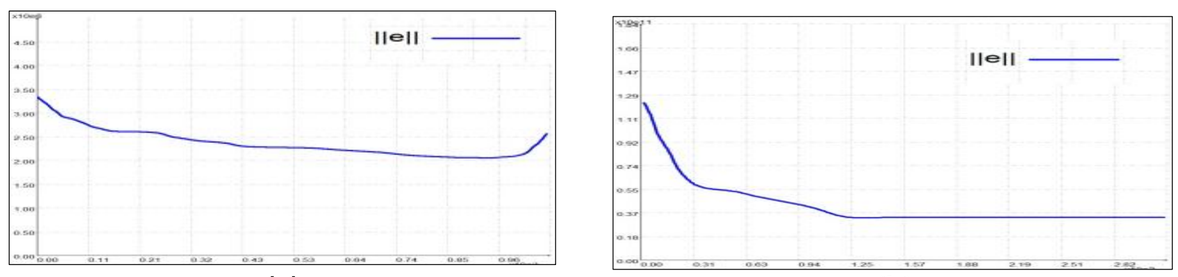
$$\boldsymbol{v_c} = -\boldsymbol{\lambda}(\boldsymbol{H(t)} + \boldsymbol{\mu diag(H(t))})^{-1}\boldsymbol{L_{sobel}^T}\boldsymbol{e_s(t)}$$

RESULTS & DISCUSSION



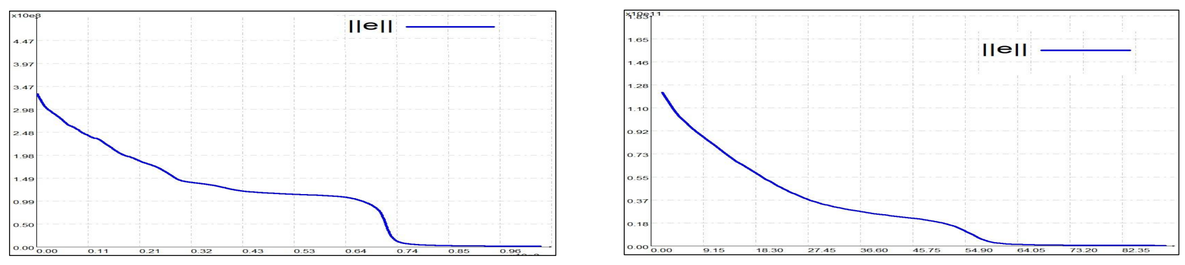
(a) (b) (c)

Figure. 1. The input images used in this study encompass three scenarios: (a) Image captured under nominal conditions, (b) Image subject to partial occlusions, (c) Image experiencing illumination variations.



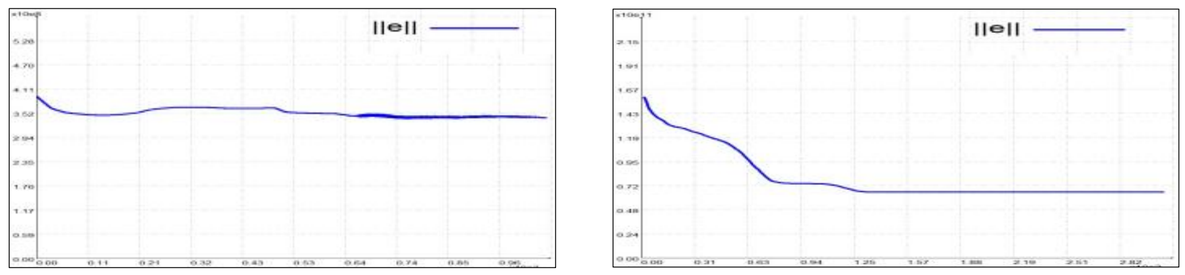
(a) (b)

Figure. 2. Results of Input Images Under Partial occlusion using: **Photometric Visual Servoing**: (a) Errors in positioning (in m and rad), **Gradient Magnitude Features**: (b) Errors in positioning (in m and rad).



(a) (b)

Figure. 3. Results of Input Images Under nominal conditions using: **Photometric Visual servoing**: (a) Errors in positioning (in m and rad), **Gradient Magnitude Features**: (b) Errors in positioning (in m and rad).



(a) (b)

Figure. 4. Results of Input Images Under Illumination variations using: **Photometric Visual servoing:** (a) Errors in positioning (in m and rad), **Gradient Magnitude Features:** (b) Errors in positioning (in m and rad).

CONCLUSION

The proposed method outperformed classical photometric visual servoing. Nonetheless, difficulties emerge when there are big differences in displacement and rotation, which increases computation time and delays convergence.

FUTURE WORK / REFERENCES

[1]F. Chaumette and S. Hutchinson, “Visual servo control. I. Basic approaches”, IEEE Robotics & Automation Magazine, vol. 13, no. 4, pp. 82–90, Dec. 2006.