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# The direct method of lines for elliptic problems in star-shaped domains<sup>☆</sup>

Zhizhang Wu<sup>a</sup>, Zhongyi Huang<sup>a,\*</sup>, Wei-Cheng Wang<sup>b</sup>, Yi Yang<sup>c</sup>

<sup>a</sup>*Department of Mathematical Sciences, Tsinghua University, Haidian District, Beijing, China*

<sup>b</sup>*Department of Mathematics, National Tsing Hua University and National Center for Theoretical Sciences, HsinChu, 300, Taiwan*

<sup>c</sup>*Department of Electrical Engineering, Tsinghua University, Haidian District, Beijing, China*

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## Abstract

In this paper, we generalize the direct method of lines for elliptic problems in star-shaped domains. We assume that the boundary of the star-shaped domain is a closed Lipschitz curve that can be parameterized by the angular variable, so that an appropriate transformation of coordinates can be introduced. Then the elliptic problem is reduced to a variational-differential problem on a semi-infinite strip in the new coordinates. We discretize the reduced problem with respect to the angular variable and obtain a semi-discrete approximation. Then a direct method is adopted to solve the semi-discrete problem analytically. Finally, the optimal error estimate of the semi-discrete approximation is given and several numerical examples are presented to show that our method is feasible and effective for a wide range of elliptic problems.

*Keywords:* Elliptic problems, Star-shaped domains, Methods of lines, Finite element approximation, Semi-discrete approximation

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\*Corresponding author.

*Email addresses:* wzz14@mails.tsinghua.edu.cn (Zhizhang Wu), zhuang@math.tsinghua.edu.cn (Zhongyi Huang), wangwc@math.nthu.edu.tw (Wei-Cheng Wang), sailors2008@sina.cn (Yi Yang)

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