The Journal of Open Source Software

AutoFunc: A Python package for automating and verifying functional modeling

Alex Mikes[1], **Katherine Edmonds**[1], **Robert B. Stone**[1], **and Bryony DuPont**[1]

1 Design Engineering Lab, Oregon State University

DOI: 10.21105/joss.02362

Software

- Review
- Repository
- Archive

Editor: George K. Thiruvathukal

Reviewers:

- @cmccomb
- @e-dub
- @srmnitc

Submitted: 21 May 2020
Published: 04 February 2021

License
Authors of papers retain copyright and release the work under a Creative Commons Attribution 4.0 International License (CC BY 4.0).

Statement of Need

Engineering design is a multi-step process that uses various iterative tools to help improve products. Each component in a product performs a corresponding set of subfunctions that contribute to the overall functionality of the product. Designers often store this product information, including components and subfunction relationships, in a database known as a design repository. In addition to storing product information, it also helpful to visualize it in a graphical representation known as a functional model. Functional modeling is a popular tool in the early design phases that helps designers ensure the product adheres to the customer requirements while maintaining the desired functionality. While significant work has been done to help increase consistency in the structure, syntax, and formatting of functional models, they are still highly subjective and time-consuming to create (Hirtz et al., 2002; Stone & Wood, 2000). Because of the time requirements, inconsistencies, and inaccuracies involved with making them, functional models are often omitted from the concept generation process, despite their useful contributions to the early stages of engineering design (Kurfman et al., 2003).

Summary

`AutoFunc` is a Python package that automatically generates the functional representations of components based on data from design repositories. The functional representations of components can be connected to form a complete functional model. `AutoFunc` also contains methods to validate and optimize the automation algorithm. A designer can use this software to input a list of components in their product, and it will automatically generate the functional representations for those components based on the most commonly seen functions and flows from previous products in the design repository. The package uses common data-mining techniques for finding information and classifying new observations based on that data. `Auto Func` also uses the common methods of cross-validation and the F1 score to find the accuracy at different values for the threshold variables.

`AutoFunc` is intended for use by engineering design researchers, students, and professionals. It has been used in several engineering design publications and presentations (Edmonds et al., 2020; Mikes et al., 2020). Further development is required to automate a complete functional model, but this software is a significant step in that direction. Automating functional modeling will help standardize the format and syntax, decrease the time required to make them, and increase the prevalence and accuracy of functional models in engineering design and design repositories. `AutoFunc` has been archived to Zenodo with the linked DOI (Mikes, 2019)

Acknowledgements

Thanks to Kyle Niemeyer for support with open software and open science.

This material is based upon work supported by the National Science Foundation under Grant No. CMMI-1826469. Any opinions, findings, and conclusions or recommendations expressed in this material are those of the author(s) and do not necessarily reflect the views of the National Science Foundation.

References

Edmonds, K., Mikes, A., Stone, Robert B, & DuPont, B. (2020). A weighted confidence metric to improve automated functional modeling. *Proceedings of the ASME 2020 International Design Engineering Technical Conferences and Computers and Information*. https://doi.org/10.1115/DETC2020-22495

Hirtz, J., Stone, R., McAdams, D., Szykman, S., & Wood, K. (2002). A functional basis for engineering design: Reconciling and evolving previous efforts. *Research in Engineering Design*, *13*, 65–82. https://doi.org/10.1007/s00163-001-0008-3

Kurfman, M. A., Stock, M. E., Stone, R. B., Rajan, J., & Wood, K. L. (2003). Experimental Studies Assessing the Repeatability of a Functional Modeling Derivation Method. *Journal of Mechanical Design*, *125*, 682–693. https://doi.org/10.1115/1.1625400

Mikes, A. (2019). *AlexMikes/AutoFunc: Automated Functional Representations* (Version v0.2.1) [Computer software]. Zenodo. https://doi.org/10.5281/zenodo.3694300

Mikes, A., Edmonds, K., Stone, Robert B, & DuPont, B. (2020). Optimizing an algorithm for data mining a design repository to automate functional modeling. *Proceedings of the ASME 2020 International Design Engineering Technical Conferences and Computers and Information*. https://doi.org/10.1115/DETC2020-22346

Stone, R. B., & Wood, K. L. (2000). Development of a Functional Basis for Design. *Journal of Mechanical Design*, *122*(4), 359. https://doi.org/10.1115/1.1289637