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Energy simulation and analysis of accessory dwelling unit: an evolutionary approach

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Abstract

The United States is experiencing an unprecedented housing crisis, resulting in a rising population of unhoused peoples and the inability to become a homeowner or to even afford monthly rent in many cities. Solutions to this dilemma are neither straightforward nor definite. Seattle, Washington; Portland, Oregon; and Vancouver, British Columbia are exploring the use of accessory dwelling units (ADUs) as one method to combat surging housing prices. Use of ADUs is an effective means of increasing housing density without replacing single family housing zones with new multi family residential construction. Additionally, ADUs are often designed to be rented, generating supplementary income for the homeowner. Ten detached ADU (or DADU) designs are pre-approved by the City of Seattle and are freely available online to entice homeowners. However, a 2019 city survey shows that there are calls for an increased focus on sustainability and cost. This research intends to explore whether the use of genetic algorithms via shape grammar methodology to optimize DADU plans to site context, increases building performance or further encourages construction. The proposed methodology begins by reading example site data from the city of Seattle including building and vegetation context and rental/land prices from Seattle GIS and Zillow, respectively. Next, a genetic algorithm explores the design space for a viable floor plan solution based on a fitness function. This fitness function evaluates individual designs according to predefined traits. Traits to evaluate include window to wall ratio, insulation depth/type, ventilation strategy, and shading technique. Locating the correct combination of traits to minimize (or maximize) which results in a higher performance DADU is the desired outcome. Resulting designs will be analyzed and compared via energy performance simulation. The end-goal is to develop a computational tool using the aforementioned system to conduct automated site analysis, as well as parametric generation of DADUs.

Keywords

Genetic Algorithm, ADU, Optimization, Simulation, EUI, Grasshopper, Galapagos

Introduction

The United States is amid an unprecedented housing crisis, stemming from issues outside of housing, such as neoliberal cuts to social benefits spending and the increasing privatization of essentially every aspect of American life. The result is a rising population of unhoused peoples and the inability for many to become a homeowner or to even afford minimum monthly rent in many cities. Solutions to this dilemma are neither straightforward nor definite. However, as designers and architects, this problem can only be addressed at the symptom-level, while advocating at the root cause.

Seattle, Washington; Portland, Oregon; and Vancouver, British Columbia are exploring the use of accessory dwelling units (ADUs) as one method to combat surging housing prices. Use of ADUs is an effective means of increasing housing density without replacing single family housing zones with new multi family residential construction. Additionally, ADUs are often designed to be rented, generating supplementary income for the homeowner. Ten detached ADU (or DADU) designs are pre-approved by the City of Seattle and are available online to entice homeowners. However, a 2019 city survey shows that there are calls for an increased focus on sustainability and cost in the construction of ADUs[1]. These out of the box designs do not offer the scalability or energy efficiency that an ADU designed specifically per site offers.

Homeowners associations and other local organizations have historically fought back against any proposed density increases through zoning or other method. However, Seattle and the other aforementioned cities in the Pacific Northwest have succeeded in allowing for the construction of ADUs in recent decades. The pre-approved designs are free, but require payment of around one thousand dollars [check this] for approval and come with one significant downside of many other pre-designed structures- a lack of contextual design and individualization.

This research explores whether the use of genetic algorithms via shape grammar methodology can effectively optimize DADU plans to site context, increases building performance or further encourages construction. The proposed methodology begins by reading example site

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data from the city of Seattle including building and vegetation context from the Seattle GIS. Next, a genetic algorithm explores the design space for a viable floor plan solution based on a fitness function. This fitness function evaluates individual designs according to predefined traits. Traits to evaluate include window to wall ratio, insulation depth/type, ventilation strategy, and shading technique. Locating the correct combination of traits to minimize (or maximize) which results in a higher performance DADU is the desired outcome. Resulting designs will be analyzed and compared via energy performance simulation. The end-goal is to develop a computational tool using the aforementioned system to conduct automated site analysis, as well as parametric generation of DADUs.

Literature Review

Methods

Design constraints and decisions

Energy simulation and analysis

Genetic algorithm

Results

Conclusion

Future work

Benefit of a pure python tool Looking forward, moving on from the Grasshopper platform gives the benefit of non-reliance on developers to maintain the software in which the tool depends. Creation of such a tool in a singular programming language (in this case Python) further offers the ability to quickly and easily run the tool on a high variance of devices. In turn, this theoretically increases the rate of adoption by lowering the requirement to use the design tool. Additionally, Python is used within Rhino/Grasshopper (or a flavor thereof), provides many useful math and geometry libraries, and has options for injection into a web app (Flask and Django). Limitations of Galapagos/Grasshopper workflow Utilizing Galapagos and Grasshopper offers a sandbox environment to begin to understand genetic algorithms and to arrive at tangible design solutions faster than using a home-brewed algorithm. Galapagos offers many fewer input parameters and a much narrower scope in which to define the fitness function. In its out-of-the-box form, Galapagos only accepts number sliders as input and can only optimize integers and floats- in reality, there is not means in which to define a true fitness function, only numerical values to target.

Figures are called in as follows:

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Declaration of conflicting interests

The author declares that there is no conflict of interest.

References

1. Seattle OoPCD. Pre-approved Plans for Accessory Dwelling Units Survey Results. URL http://www.seattle.gov/Documents/Departments/OPCD/OngoingInitiatives/EncouragingBackyardCottages/OPCDPreApprovedDADUSurveySummary.pdf.