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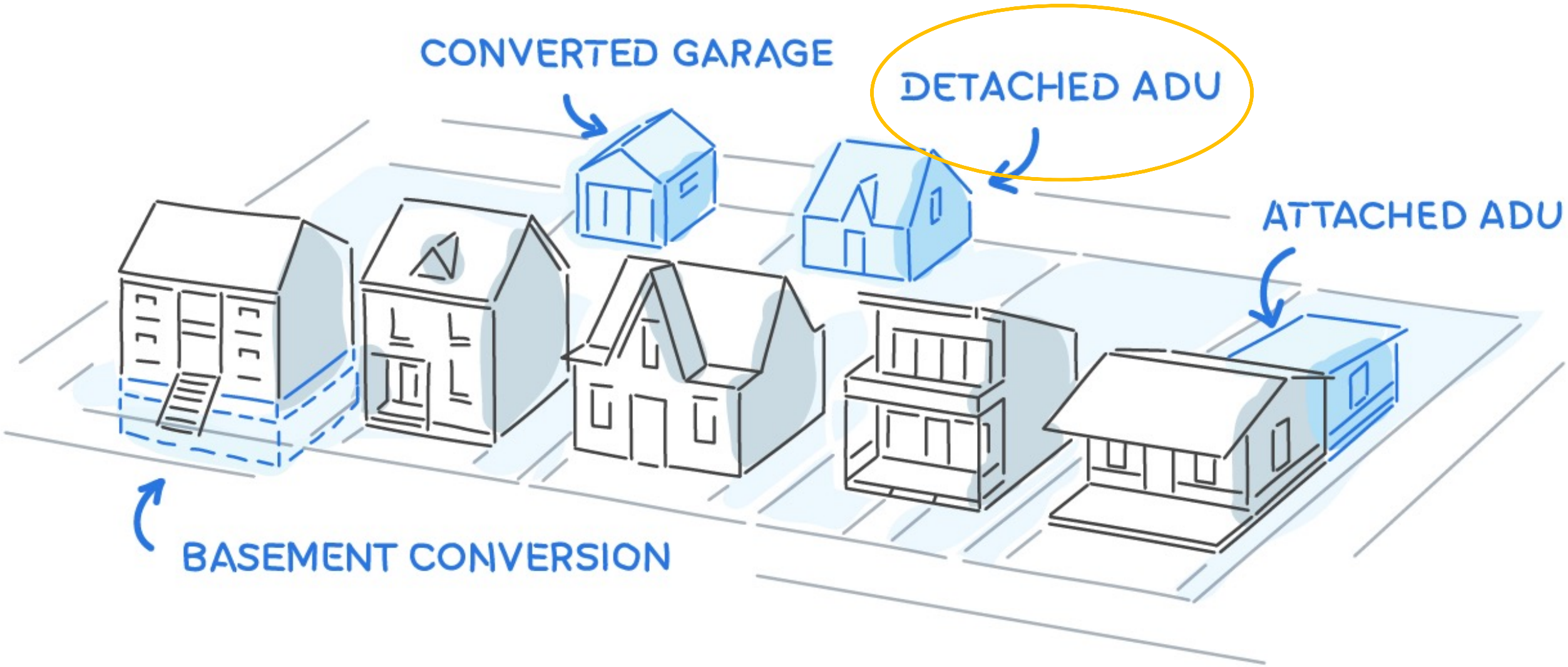
SURROGATE ENERGY MODELING TOOL FOR ACCESSORY DWELLING UNITS AND POTENTIAL POLICY IMPLICATIONS

preston pape

STATISTICS

- 44 million renters in united states
- more than 47% of these are rent-burdened (household spending >30% of gross income on rent and utilities, as defined by HUD)
- since 1961, median home prices have increased by 121%, whereas median household income has only increased by 29%
- those with <80% median area income spend average of 7.2%-25% on energy utility costs
  - seattle: ECB = 2% (~$1700)

https://kinder.rice.edu/urbanedge/2019/07/25/gap-between-income-growth-and-housing-cost-increases-continues-grow



https://www.housable.com/city/sacramento-ca-179074

ADU BENEFITS:

- reduced space occupied per person for healthy living
- increased home value to property owner
- enables affordable inclusion for low-income residents
- offers proximity to better public schools
- increased walkability (15 min. city)
- helps to stabilize rental prices by increasing supply without sprawl
- enables the elderly to remain independent

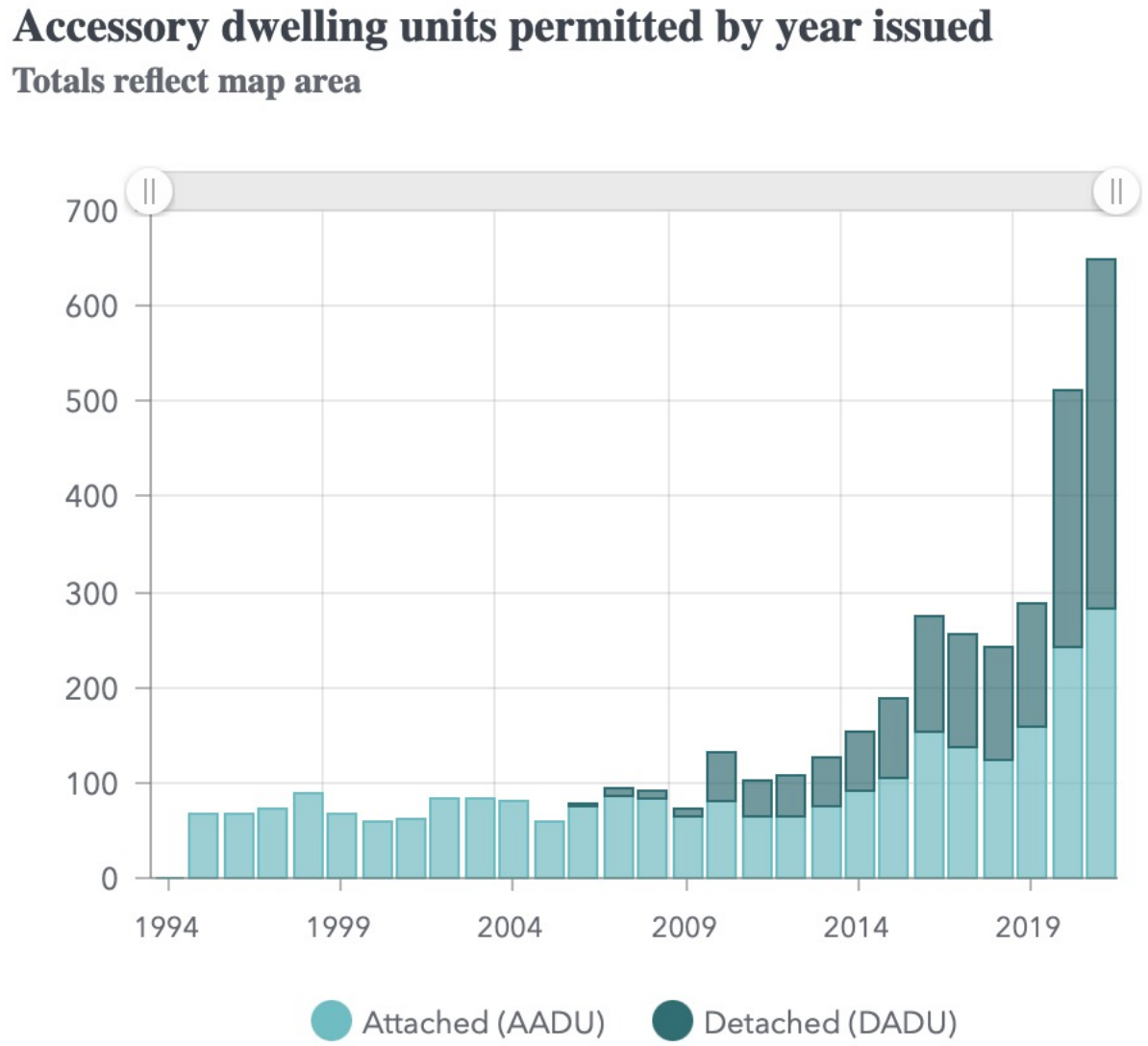
https://aduniverse-seattlecitygis.hub.arcgis.com/pages/gallery

STATE OF ADUS IN SEATTLE

- pre-approved DADU designs via city
- large uptick in construction
- housing goals still not met:
  - nearly 1.8 million new residents by 2050

however:

- many are low-performance
- ~260 new DADUs in 2020, when 100,000 properties eligible



https://aduniverse-seattlecitygis.hub.arcgis.com/pages/data

RESEARCH QUESTIONS

- can a machine learning powered design tool reduce carbon and energy use while increasing production of DADUs in seattle?
    - what is the effect of empowering potential owners to see energy quantities beforehand?
    - which design constraints impact DADU energy use greatest?
- how does the energy performance of the 10 pre-approved designs compare to a site-specific DADU design?
- can results generated by tool verify city planning policy initiatives?

COMPARATIVE ANALYSIS: pre-approved DADU plans

- simulation of ten existing DADU designs (pre-approved for permitting)
- analyze and compare energy/carbon
- compare to site-designed DADU using tool once complete
- give feedback to city regarding results

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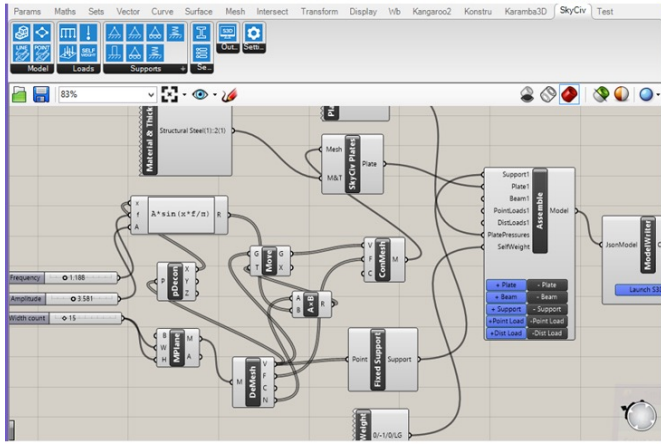
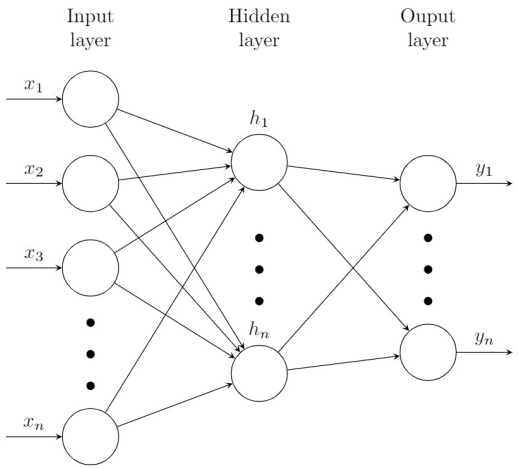
DEVELOPMENT PIPELINE

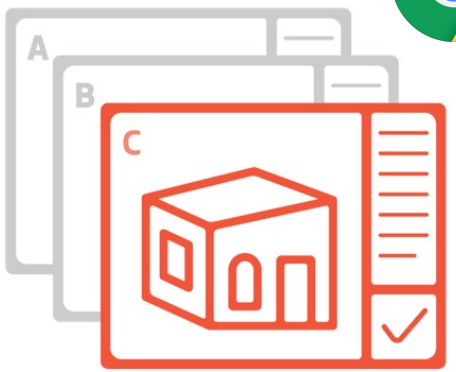
mass simulation of design inputs using energyplus via grasshopper



polynomial regression
random forest
neural network



web-based, real-time EUI + carbon design tool



https://tex.stackexchange.com/questions/497859/neural-network-diagram

https://aduniverse-seattlecitygis.hub.arcgis.com/pages/gallery

SIMULATION DESIGN SPACE (inputs)

CURRENT

- location: seattle EPW (1)
- lot type: infill vs. corner (2)
- lot access: alley vs. no alley (2)
- # of ADUs: 1-2; 1-5 (2) *or* (5)
- WWR: low vs. medium vs. high (3)
- insulation mat (2-3)
- facade mat (2-4)
- etc..

POTENTIAL

- site: retain trees vs. cut (2)
- sqft. variance (FAR) (?)
- setbacks: existing vs. reduced (2)

total simulations: 172800+

target run time/simulation: ~8s

total time: 2 days

SIMULATION DESIGN SPACE (outputs)

PRIMARY

- energy use intensity (EUI)
- embodied carbon

SECONDARY

- operational carbon
- total carbon

POTENTIAL

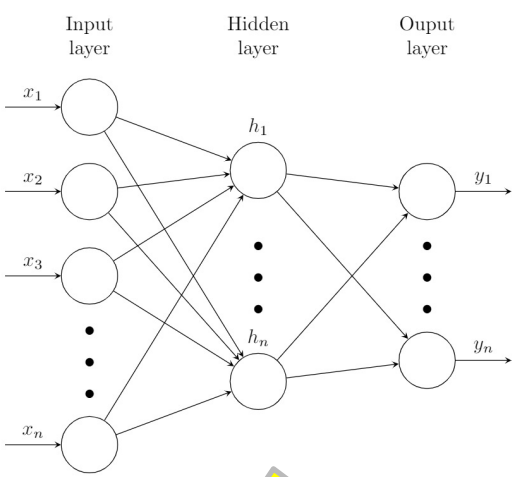
- EUI/capita
- total carbon/capita
- other created metrics

results archived as JSON files

-> converted to .csv

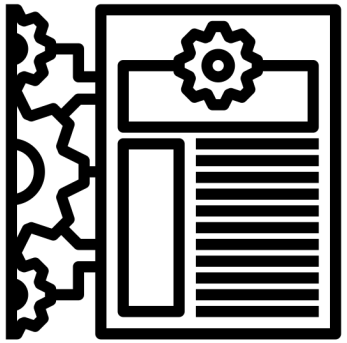
-> read into either scikit-learn- or pytorch-based learning model

UTILIZATION PIPELINE



optimization of model via usage of tool

insights drawn from results to backup key planning policy initiatives



(seattle office of planning and community development)

THANK YOU

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