



SIGGRAPH
ASIA 2019
BRISBANE



Data-driven Interior Plan Generation for Residential Buildings



sa2019.siggraph.org

Wenming Wu¹ Xiao-Ming Fu¹ Rui Tang² Yuhan Wang² Yu-Hao Qi¹ Ligang Liu¹

¹University of Science and Technology of China ²Kujiale



**SIGGRAPH
ASIA 2019
BRISBANE**

Interior plan

- Designing floor plans for residential buildings
- Architectural scenes in computer games and virtual worlds



House design



Computer game



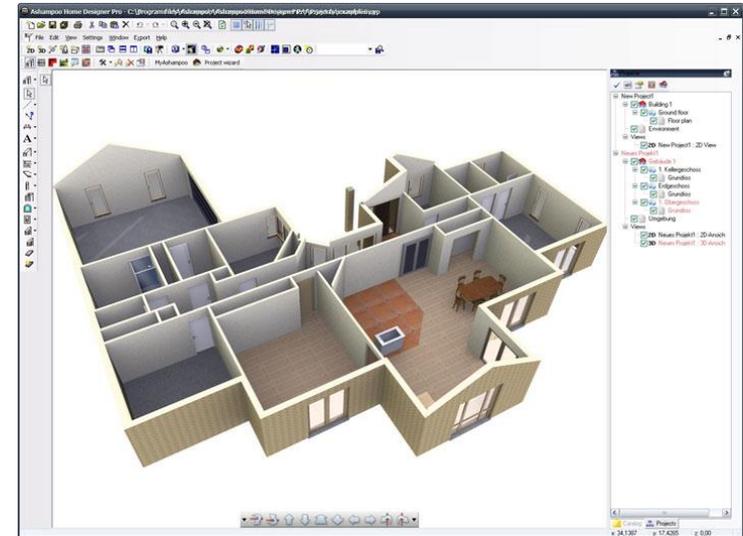
**SIGGRAPH
ASIA 2019
BRISBANE**

Motivation

- An iterative trial-and-error and time-consuming process



Interactive tool



Assistant tool



**SIGGRAPH
ASIA 2019
BRISBANE**

Goal: automatic generation

- Automate design for residential buildings
- Quick and high-quality generation



Plausible floor plan



SIGGRAPH
ASIA 2019
BRISBANE

Related work

- Computer-generated residential building layouts [Merrell et al. 2010]
- Computing layouts with deformable templates [Peng et al. 2014]
- MIQP-based Layout Design for Building Interiors [Wu et al. 2018]
- More ...

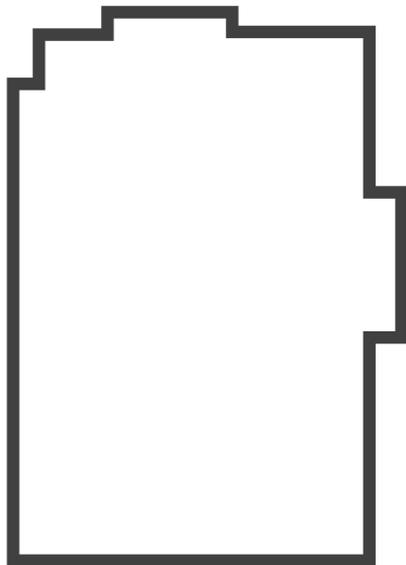




**SIGGRAPH
ASIA 2019
BRISBANE**

Problem statement

- Generate floor plans given the building boundary as input



Input floor plan



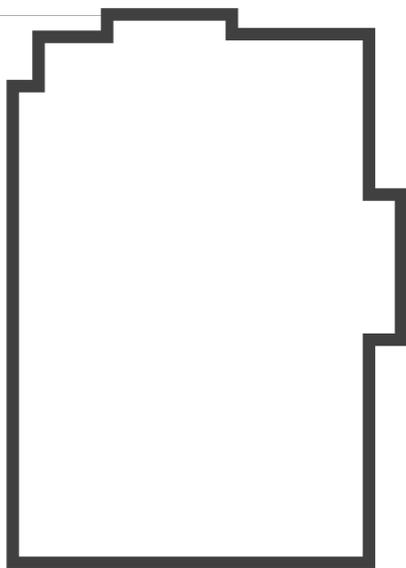
Output floor plan



SIGGRAPH
ASIA 2019
BRISBANE

Problem statement

- A data-driven method for floor plan generation



Input floor plan



Data-driven



Output floor plan



SIGGRAPH
ASIA 2019
BRISBANE

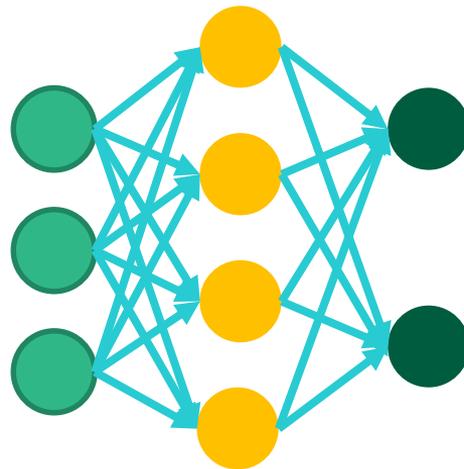
Challenges

- A large-scale dataset consisting of real floor plans with annotations
- A non-trivial learning approach to generate high-quality floor plans

Dataset



Network

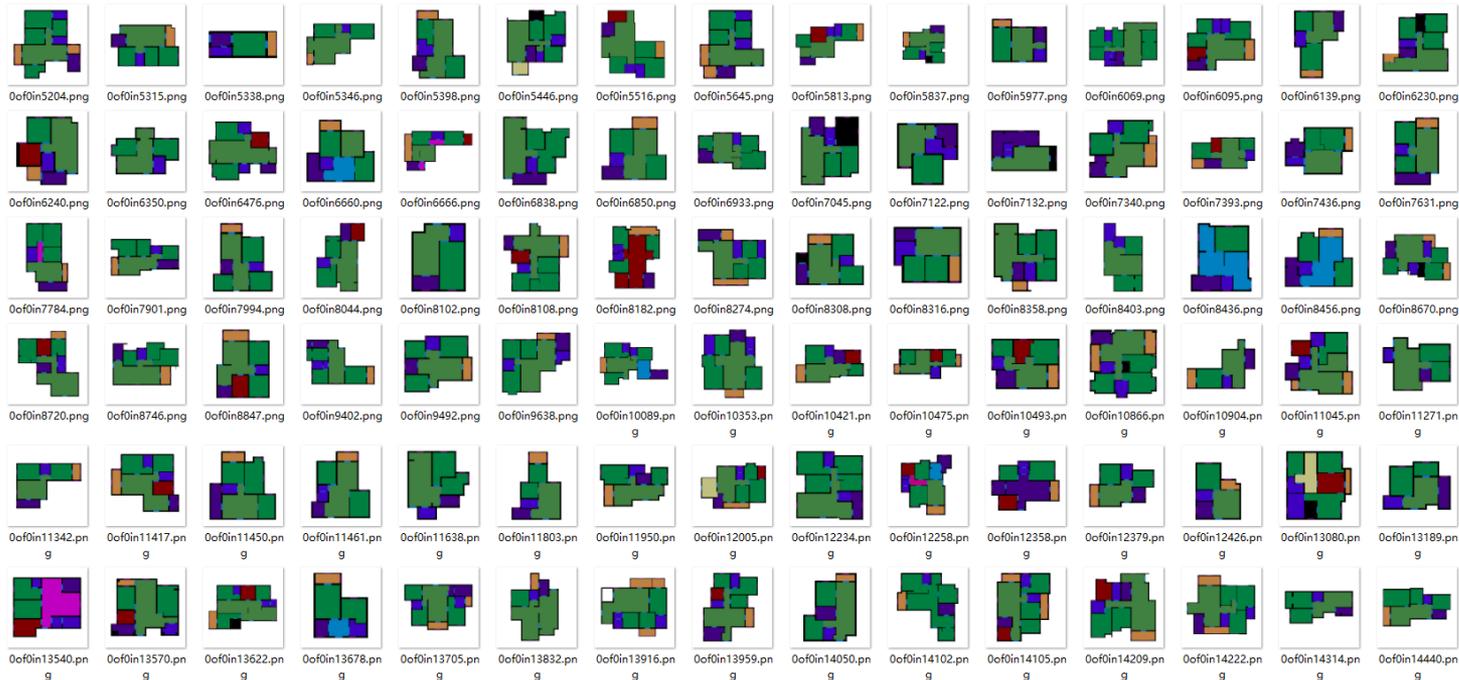




SIGGRAPH
ASIA 2019
BRISBANE

Dataset of *RPLAN*

- A large-scale dataset containing more than 80K real-world floor plans





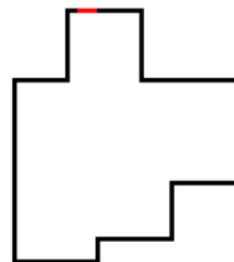
**SIGGRAPH
ASIA 2019
BRISBANE**

Data representation

- A four-channel image (256x256) represent a squared region (18mx18m)



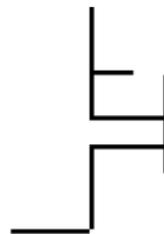
Floor plan



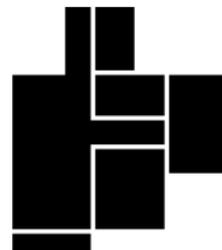
Boundary mask



Inside mask



Wall mask



Room mask

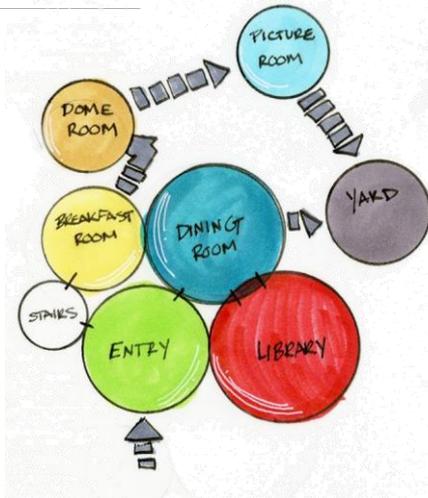
Ground truth



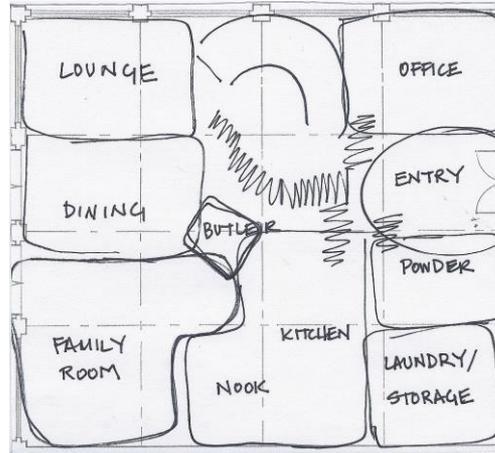
**SIGGRAPH
ASIA 2019
BRISBANE**

Design process of designers

- Determining room connections and positions
- Computing room sizes and wall positions



Bubble graph



Initial draft



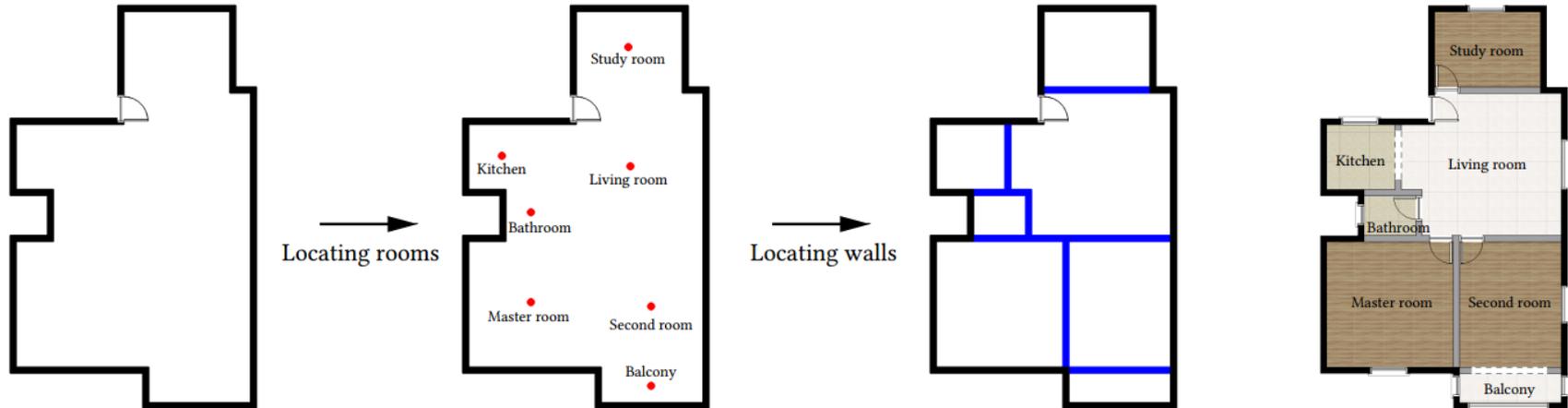
Final design



SIGGRAPH
ASIA 2019
BRISBANE

Approach

- A two-stage approach that imitates the human design process by locating rooms first and then walls



Two-stage approach



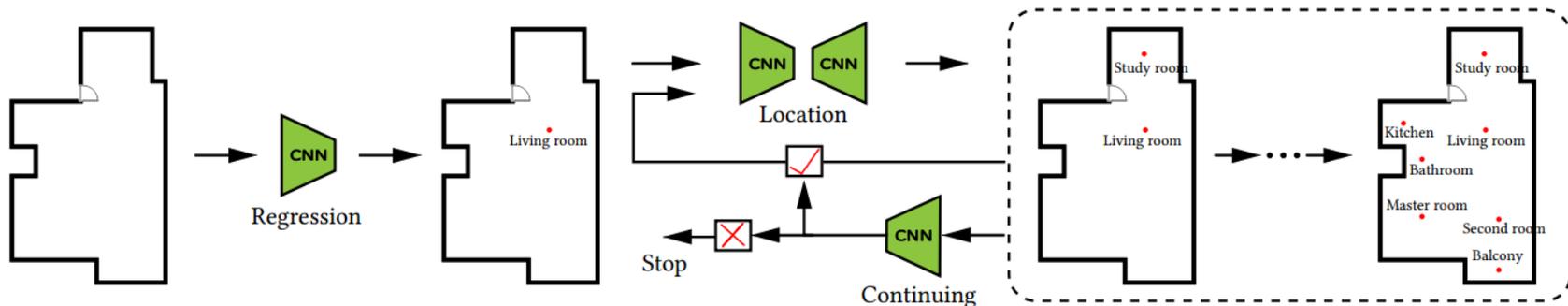
SIGGRAPH
ASIA 2019
BRISBANE

Stage one: locating rooms

Iterative strategy:

- (1) Computing the location of the living room
- (2) Deciding what type of room to add and where
- (3) Deciding whether to add another room.

If yes, go to Step (2); otherwise stop the algorithm



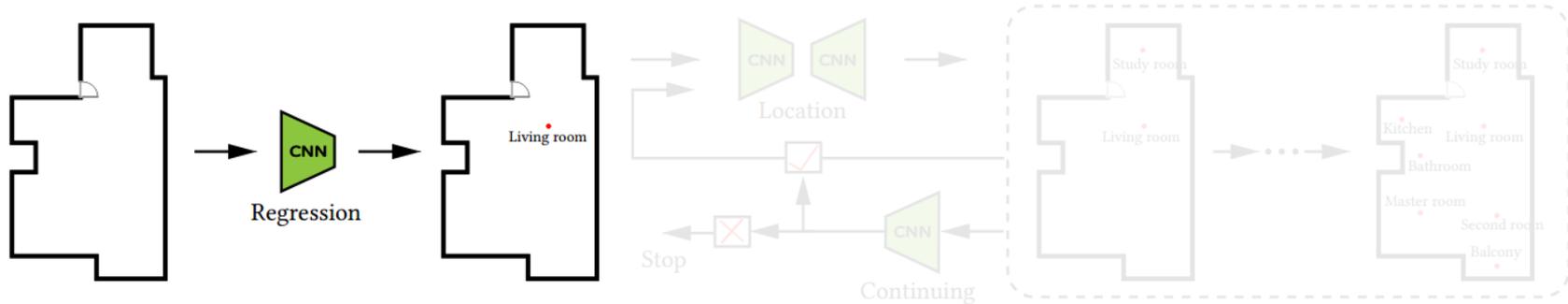


SIGGRAPH
ASIA 2019
BRISBANE

Living room first strategy

Living room first strategy:

- An indispensable part in the modern residence
- Located in the central area of the floor plan
- Connected to most other rooms

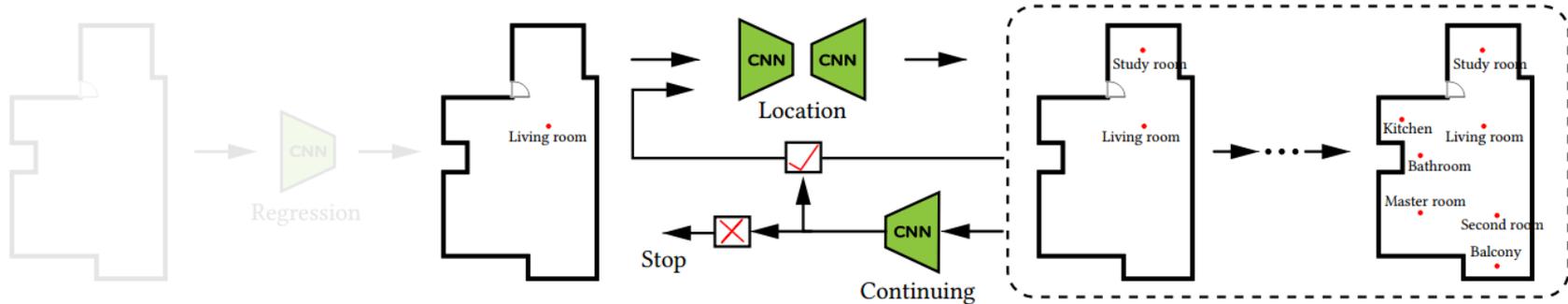




SIGGRAPH
ASIA 2019
BRISBANE

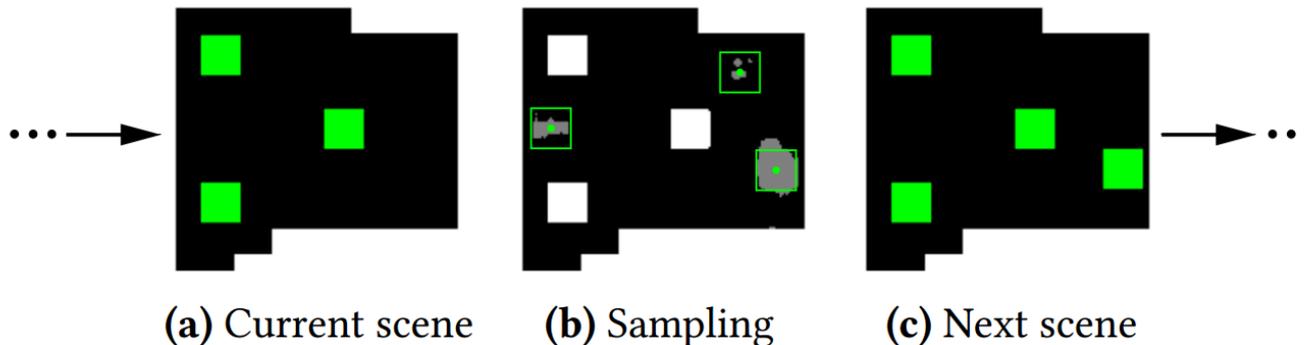
Room type and location

- An encoder-decoder network to predict room types and locations
- An iterative process to add rooms into the scene



Sampling

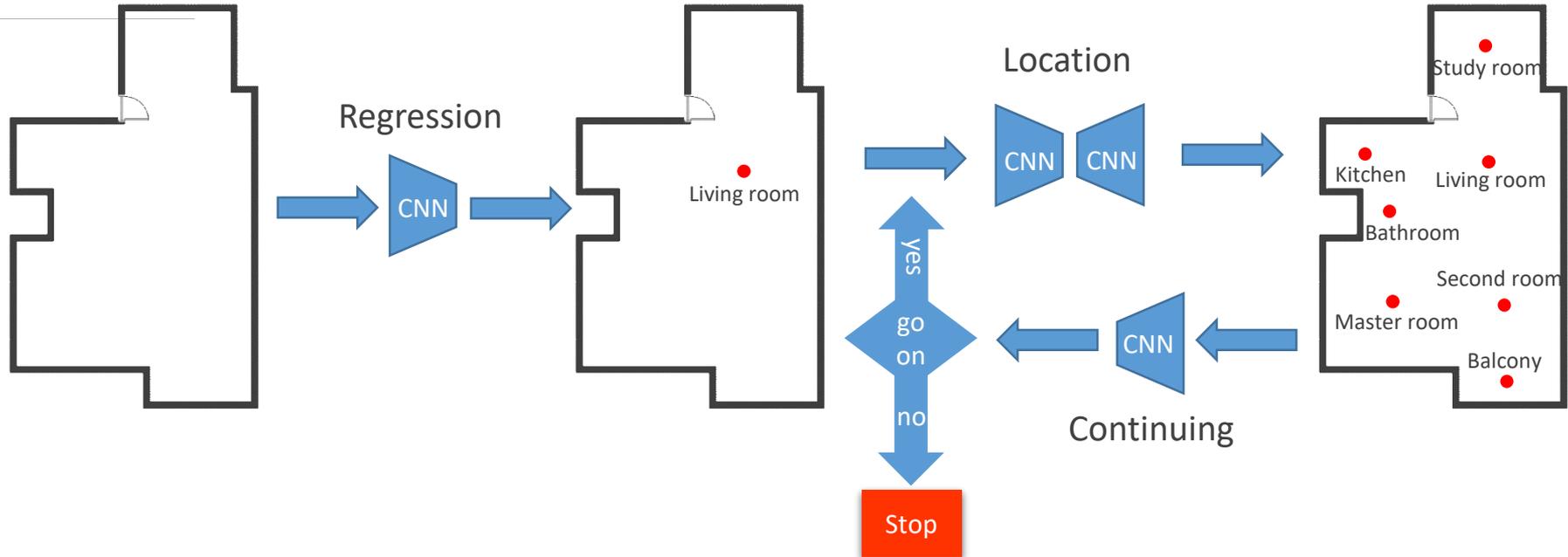
- A robust sampling method to reduce the impact of the noise





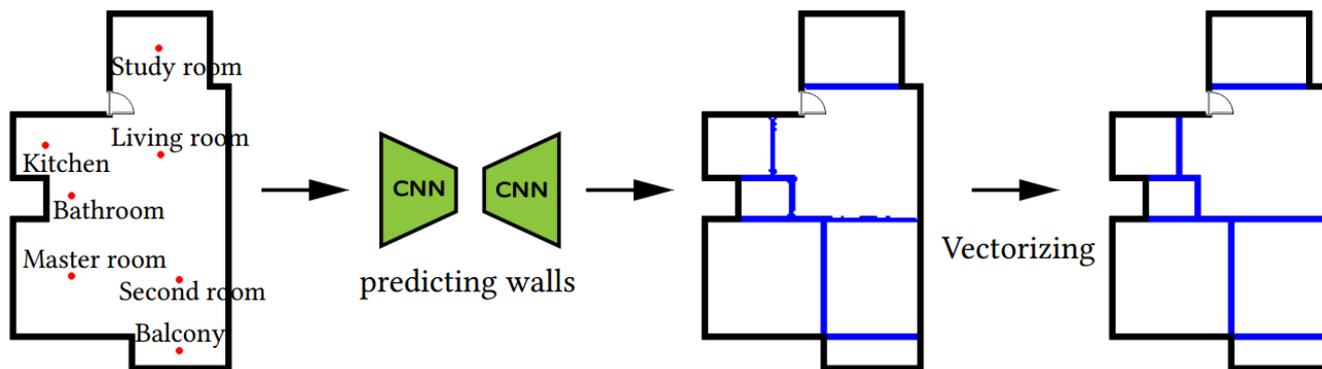
SIGGRAPH
ASIA 2019
BRISBANE

Locating rooms



Stage two: locating walls

- A prediction-based wall locating strategy

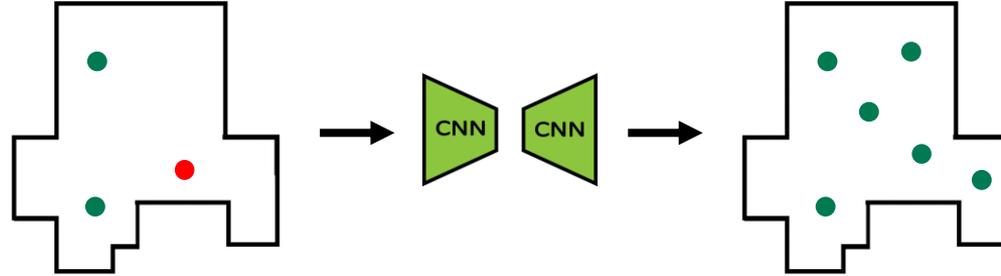




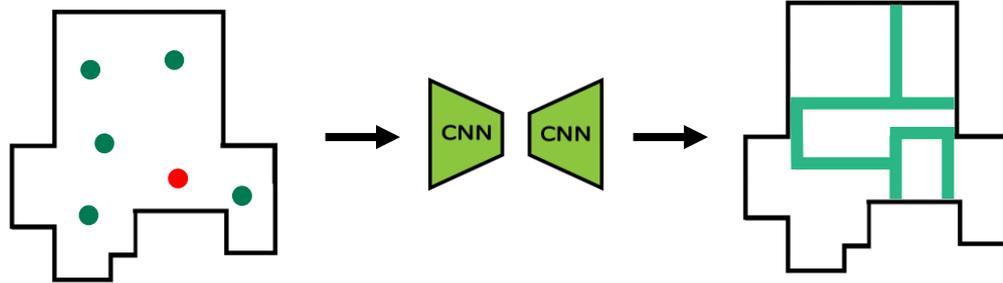
SIGGRAPH
ASIA 2019
BRISBANE

Encoder-decoder prediction

Locating rooms

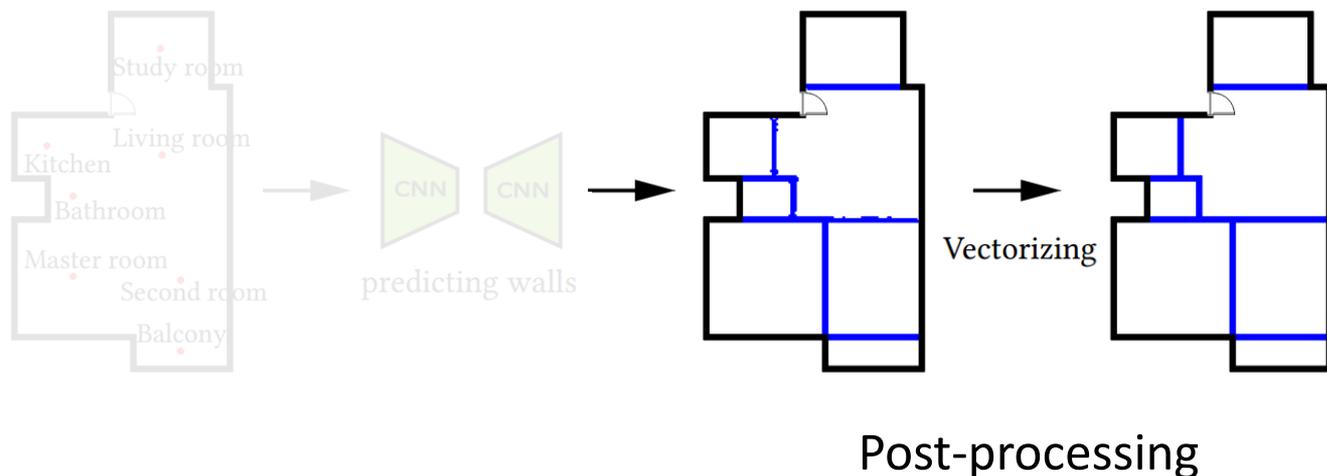


Locating walls



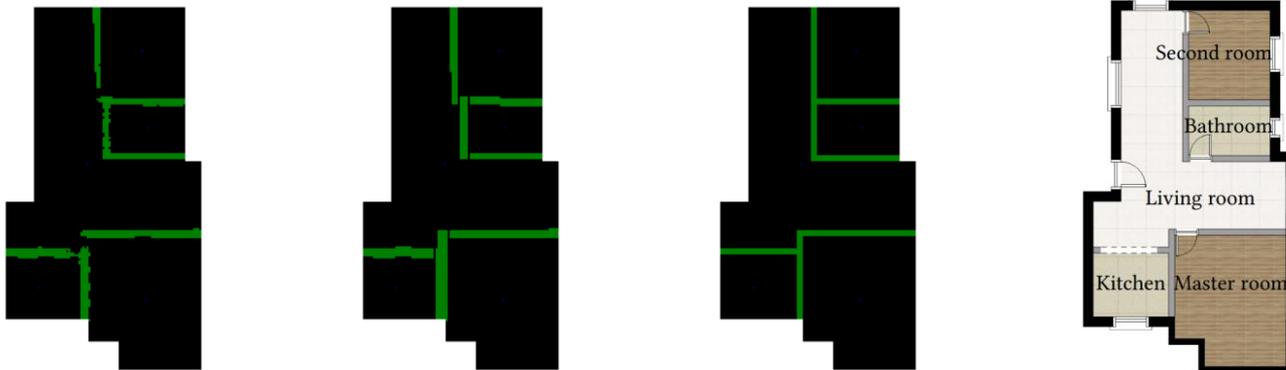
Vectorization

- Convert the predicted wall map into the final vector format



Vectorization

- Convert the predicted wall map into the final vector format





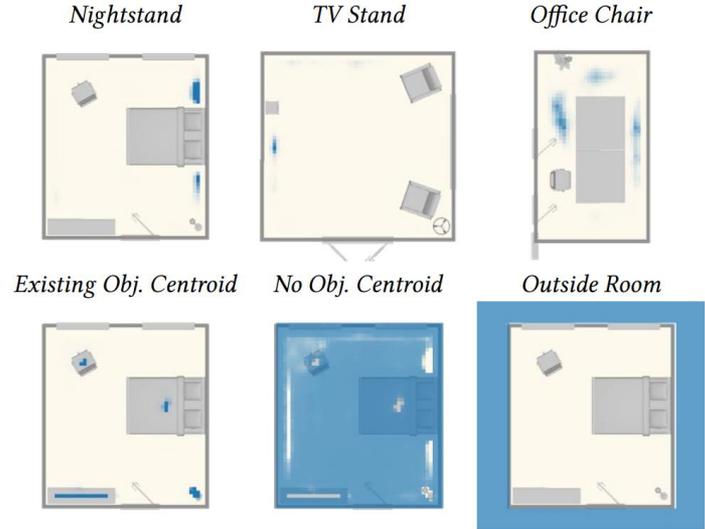
SIGGRAPH
ASIA 2019
BRISBANE

User study

- State-of-the-art methods for layout synthesis in computer graphics



Wu et al. 2018
MIQP



Wang et al. 2018
ISSNet

User study

- Cross combination between state-of-the-art methods and our method to construct our competitors

(1) ISSNet+MIQP: [Wang et al. 2018] + [Wu et al. 2018]

(2) Stage1+MIQP: Our networks for locating rooms + [Wu et al. 2018]

(3) ISSNet+Stage2: [Wang et al. 2018] + Our network for locating walls

(4) Human: Human-created floor plans

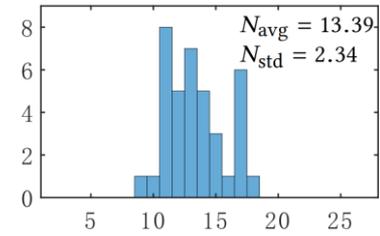
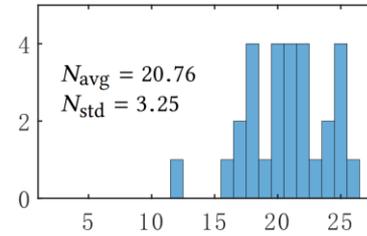
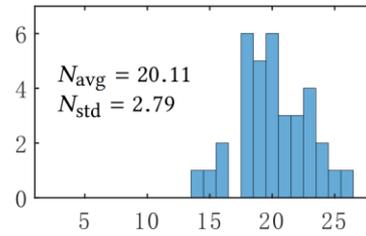
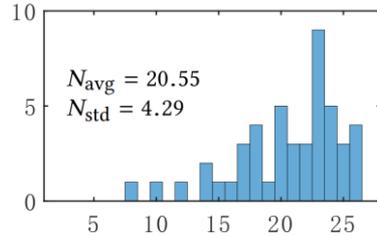


SIGGRAPH
ASIA 2019
BRISBANE

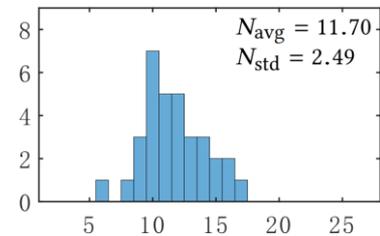
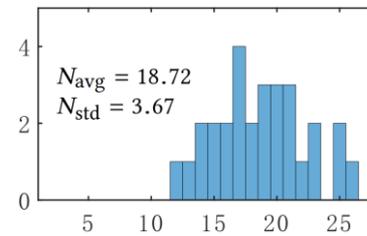
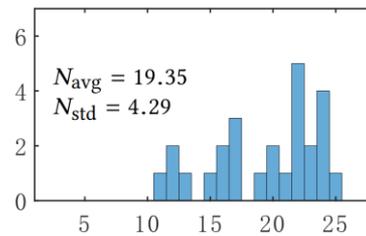
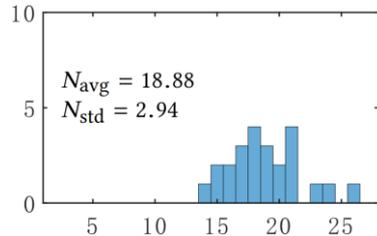
User study

- Distributions of the number of floor plans that are generated by our method and preferred by that participant

General
Users



Designers



ISSNet+MIQP

Stage1+MIQP

ISSNet+Stage2

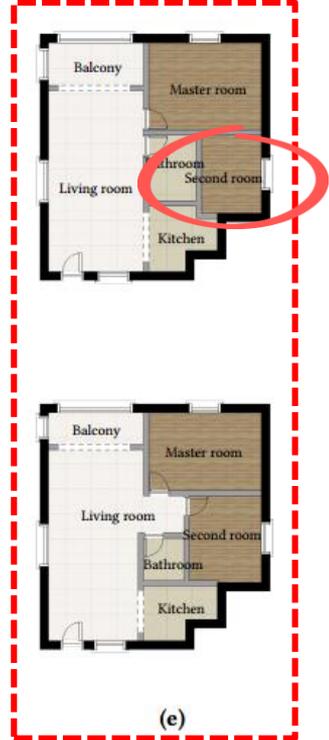
Human



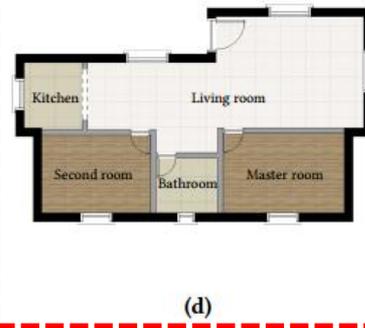
SIGGRAPH
ASIA 2019
BRISBANE

Comparison to ISSNet+MIQP

Competitor



Our method



(a)

(b)

(c)

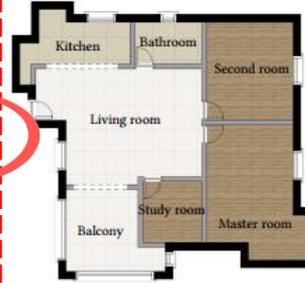
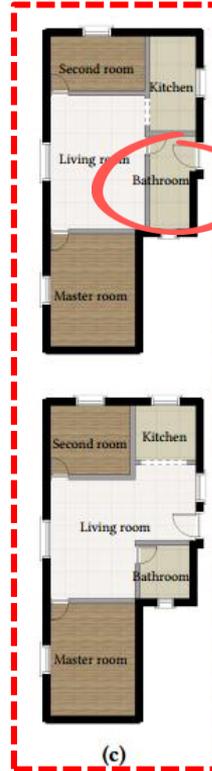
(d)

(e)



SIGGRAPH
ASIA 2019
BRISBANE

Competitor



Our method



(a)

(b)

(c)

(d)

(e)

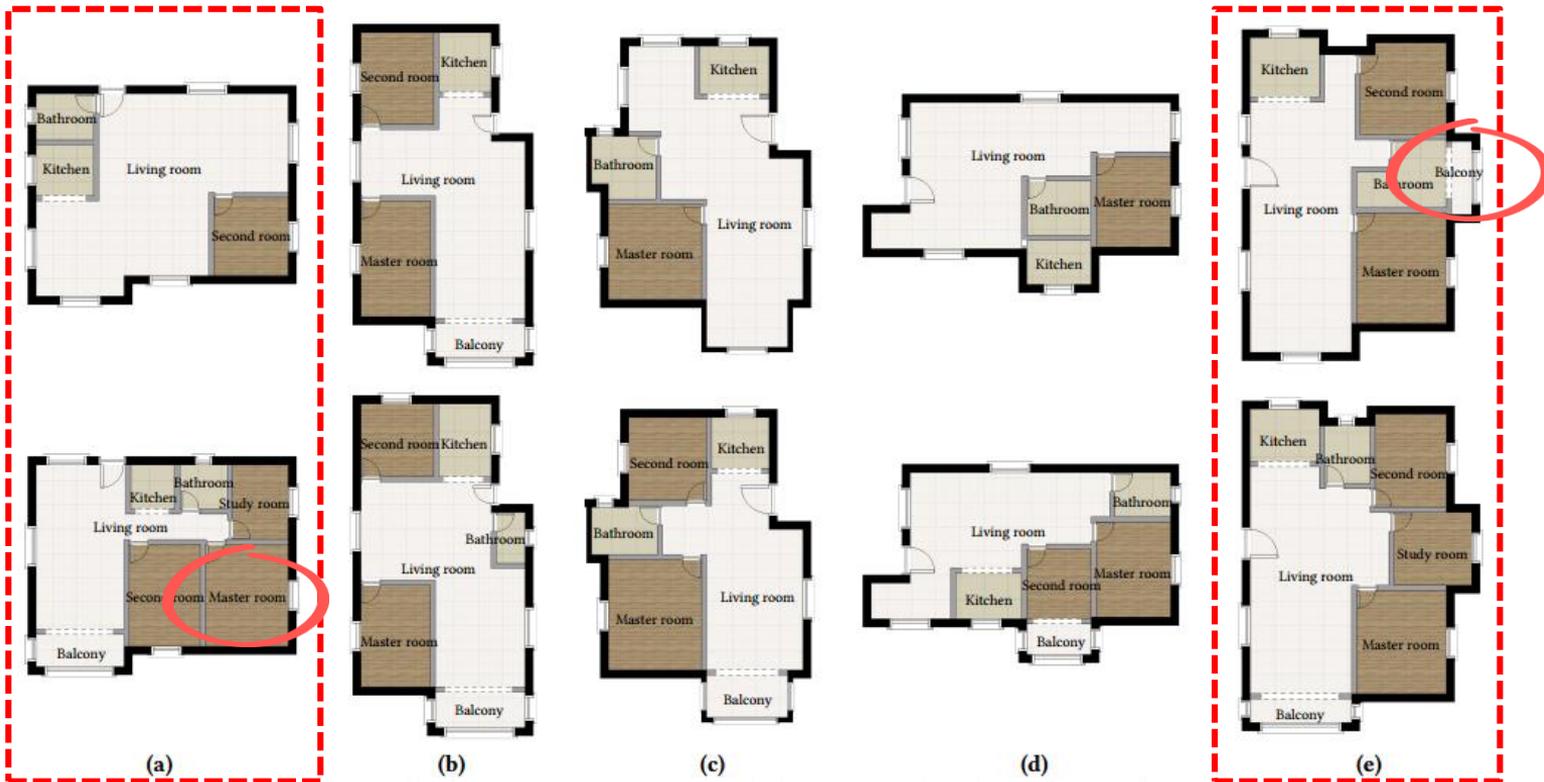
Comparison to Stage1+MIQP



SIGGRAPH
ASIA 2019
BRISBANE

Comparison to ISSNet+Stage2

Competitor



Our method





SIGGRAPH
ASIA 2019
BRISBANE

Comparison to Human

Competitor



Our method



(a)

(b)

(c)

(d)

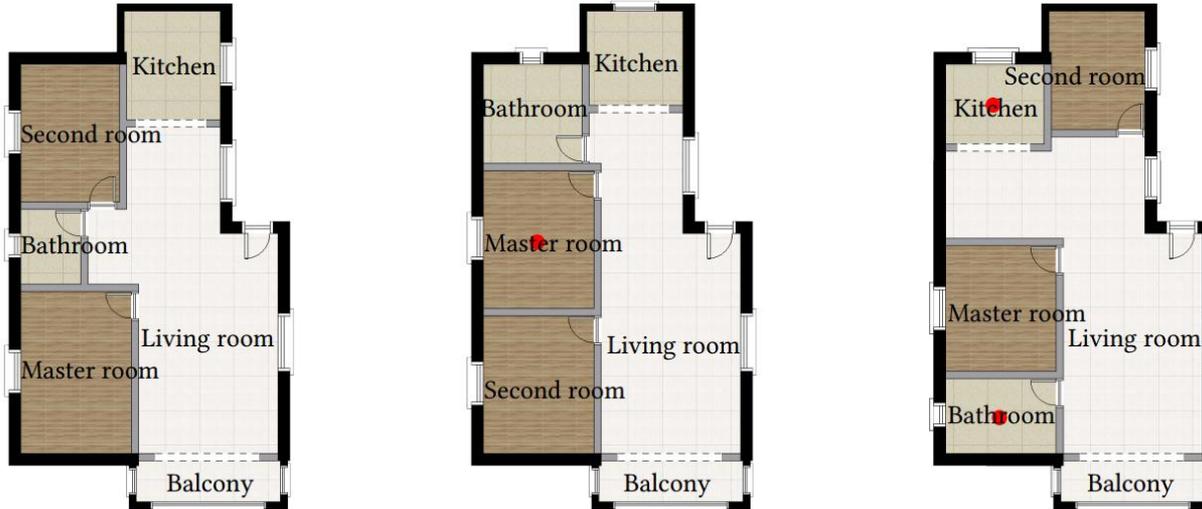
(e)



**SIGGRAPH
ASIA 2019
BRISBANE**

Room constraints

- Examples of floor plans generated by our method, given one or two room locations specified by users





SIGGRAPH
ASIA 2019
BRISBANE

The nearest neighbors



Our synthesized results



Nearest neighbors



SIGGRAPH
ASIA 2019
BRISBANE

Non axis-aligned input

- Floor plan generation for non axis-aligned boundaries





**SIGGRAPH
ASIA 2019
BRISBANE**

Multiple floor plans

- Synthesize multiple floor plans given the same boundary as input





Conclusion

- A novel data-driven technique to generate floor plans for residential buildings with fixed boundary
- A large-scale dataset containing more than 80K floor plans from real residential buildings



SIGGRAPH
ASIA 2019
BRISBANE

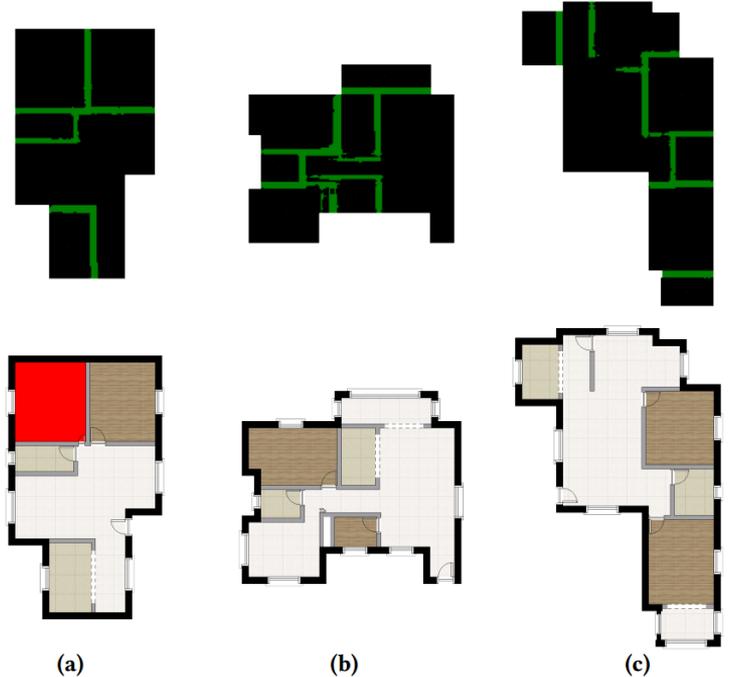
Limitations

- Inappropriate arrangements
- Poor wall predictions
- Problematic vectorization

Future work

- Constraints in real life
- More types of buildings

Conclusion



Failure case



Acknowledgements

- All participants of user studies
- Kai Wang[Wang et al. 2018]), Brown University
- All anonymous reviewers
- All funding agencies





SIGGRAPH
ASIA 2019
BRISBANE

Thank you

Wenming Wu

sa2019.siggraph.org

