Redefining the home of the next generation in Toronto Laneways

by:
Theodore Wong

A millennial housing typology

A thesis submitted in partial fulfillment of the requirements for the degree of Master of Architecture

The Faculty of Graduate Studies
Laurentian University
Sudbury, Ontario, Canada

© Theodore Wong 2019
Title of Thesis
Titre de la thèse
A Millennial Housing Typology: Redefining the Home of the Next Generation in Toronto Laneways

Name of Candidate
Nom du candidat
Wong, Theodore

Degree
Diplôme
Master of

Department/Program
Département/Programme
Architecture

Date of Defence
Date de la soutenance
April 08, 2019

APPROVED/APPROUVÉ

Thesis Examiners/Examinateurs de thèse:

Randall Kober
(Thesis Advisor / Directeur(trice) de thèse)

Dr. David Fortin
(Thesis Second Reader / Directeur(trice) de thèse deuxième)

Approved for the Faculty of Graduate Studies
Approuvé pour la Faculté des études supérieures
Dr. David Lesbarrères
Monsieur David Lesbarrères

Ms. Janna Levitt
(External Examiner/Examinateur(trice) externe)

Dean, Faculty of Graduate Studies
Doyen, Faculté des études supérieures

ACCESSIBILITY CLAUSE AND PERMISSION TO USE

I, Theodore Wong, hereby grant to Laurentian University and/or its agents the non-exclusive license to archive and make accessible my thesis, dissertation, or project report in whole or in part in all forms of media, now or for the duration of my copyright ownership. I retain all other ownership rights to the copyright of the thesis, dissertation or project report. I also reserve the right to use in future works (such as articles or books) all or part of this thesis, dissertation, or project report. I further agree that permission for copying of this thesis in any manner, in whole or in part, for scholarly purposes may be granted by the professor or professors who supervised my thesis work or, in their absence, by the Head of the Department in which my thesis work was done. It is understood that any copying or publication or use of this thesis or parts thereof for financial gain shall not be allowed without my written permission. It is also understood that this copy is being made available in this form by the authority of the copyright owner solely for the purpose of private study and research and may not be copied or reproduced except as permitted by the copyright laws without written authority from the copyright owner.
Author's Declaration

I hereby declare that I am the sole author of this thesis. This is a true copy of the thesis, including any required final revisions, as accepted by my examiners.

I understand that my thesis may be made electronically available to the public.
Abstract

The “millennial” has become a prominent term in today’s society and culture. “millennials” refers to a generation of young adults born between the early 1980s and 2000.1 Made up of over 92 million people this generation is larger than the Baby Boomers2, and have a huge influence on the world’s economy, social policies, culture, and urban fabric. As of 2018, the millennial generation will have an annual spending of 3.39 trillion dollars, surpassing the Baby Boomer generation in buying power.3 However, millennials have inherited a different circumstance from the previous generation, dramatically changing the social, cultural, and economic needs of the millennials. Challenges such as climate change, the housing bubble, and an inflated economy, influence the possibilities of future home ownership for this generation. Additionally, the element of technology is intertwined with the day-to-day of millennials. How might technology manifest itself within architecture of the future? And how will architecture adapt to suit the needs and desires of the upcoming generation?

Keywords: millennial, housing, technology, toronto, laneway house, smart home

2   Baby Boomer - descriptive term for a person who was born between 1946 and 1964
I would like to thank Randy for guiding me throughout the process of the thesis, as well as David, Patrick and Terrance for their feedback and comments. Thank you to Janna Levitt for reviewing the project as the external reader. And thanks to Steven for his help in the development of the arduino prototypes.

Many thanks to all the members of the Laurentian Architecture charter class for six outrageous years and especially, Edward, Hamza, Jess, Justin, Matwij, Suvik, Tony and Yu-Bing for their invaluable support and constant encouragement.

Lastly, I would like to thank my parents who have sacrificed so much so that I could follow my dreams.
<table>
<thead>
<tr>
<th>Section</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>authors declaration</td>
<td>iii</td>
</tr>
<tr>
<td>abstract</td>
<td>iv</td>
</tr>
<tr>
<td>acknowledgments</td>
<td>v</td>
</tr>
<tr>
<td>list of figures</td>
<td>viii</td>
</tr>
<tr>
<td>introduction</td>
<td>13</td>
</tr>
<tr>
<td>who are the millennials</td>
<td>16</td>
</tr>
<tr>
<td>a generational change in dwelling</td>
<td>22</td>
</tr>
<tr>
<td>toronto as the site</td>
<td>32</td>
</tr>
<tr>
<td>case studies</td>
<td>40</td>
</tr>
<tr>
<td>intelligent spaces</td>
<td>44</td>
</tr>
<tr>
<td>a prototype for millennial housing</td>
<td>76</td>
</tr>
<tr>
<td>conclusion</td>
<td>131</td>
</tr>
<tr>
<td>Num.</td>
<td>Page</td>
</tr>
<tr>
<td>------</td>
<td>------</td>
</tr>
<tr>
<td>1.1</td>
<td>15</td>
</tr>
<tr>
<td>2.2</td>
<td>18</td>
</tr>
<tr>
<td>3.2</td>
<td>24</td>
</tr>
<tr>
<td>3.4</td>
<td>25</td>
</tr>
<tr>
<td>3.5</td>
<td>26</td>
</tr>
<tr>
<td>3.9</td>
<td>30</td>
</tr>
<tr>
<td>3.10</td>
<td>31</td>
</tr>
<tr>
<td>4.2</td>
<td>34</td>
</tr>
<tr>
<td>Num.</td>
<td>Page</td>
</tr>
<tr>
<td>-------</td>
<td>------</td>
</tr>
<tr>
<td>4.3 - 4.11</td>
<td>36</td>
</tr>
<tr>
<td>4.12 - 4.20</td>
<td>37</td>
</tr>
<tr>
<td>4.12 - 4.20</td>
<td>37</td>
</tr>
<tr>
<td>4.21</td>
<td>38</td>
</tr>
<tr>
<td>6.2</td>
<td>47</td>
</tr>
<tr>
<td>6.3</td>
<td>48</td>
</tr>
<tr>
<td>6.5</td>
<td>50</td>
</tr>
<tr>
<td>6.6</td>
<td>51</td>
</tr>
<tr>
<td>6.7</td>
<td>52</td>
</tr>
<tr>
<td>6.8</td>
<td>53</td>
</tr>
<tr>
<td>6.9</td>
<td>54</td>
</tr>
<tr>
<td>6.10</td>
<td>55</td>
</tr>
<tr>
<td>Num.</td>
<td>Page</td>
</tr>
<tr>
<td>------</td>
<td>------</td>
</tr>
<tr>
<td>6.11</td>
<td>56</td>
</tr>
<tr>
<td>6.12</td>
<td>57</td>
</tr>
<tr>
<td>6.13</td>
<td>58</td>
</tr>
<tr>
<td>6.14</td>
<td>60</td>
</tr>
<tr>
<td>6.15</td>
<td>62</td>
</tr>
<tr>
<td>6.16</td>
<td>64</td>
</tr>
<tr>
<td>6.17</td>
<td>65</td>
</tr>
<tr>
<td>6.18</td>
<td>66</td>
</tr>
<tr>
<td>6.19</td>
<td>69</td>
</tr>
<tr>
<td>6.20</td>
<td>71</td>
</tr>
<tr>
<td>6.21</td>
<td>72</td>
</tr>
<tr>
<td>7.1</td>
<td>74</td>
</tr>
<tr>
<td>7.2</td>
<td>76</td>
</tr>
<tr>
<td>7.3</td>
<td>80</td>
</tr>
<tr>
<td>7.4</td>
<td>81</td>
</tr>
<tr>
<td>7.5</td>
<td>82</td>
</tr>
<tr>
<td>7.6</td>
<td>84</td>
</tr>
<tr>
<td>7.7</td>
<td>86</td>
</tr>
<tr>
<td>7.8</td>
<td>88</td>
</tr>
<tr>
<td>7.9</td>
<td>90</td>
</tr>
<tr>
<td>7.14</td>
<td></td>
</tr>
</tbody>
</table>
## List of Figures

<table>
<thead>
<tr>
<th>Num.</th>
<th>Page</th>
<th>Source</th>
</tr>
</thead>
<tbody>
<tr>
<td>7.16 - 7.21</td>
<td>82</td>
<td>Module 2 Axonometric diagrams, by author.</td>
</tr>
<tr>
<td>7.22</td>
<td>104</td>
<td>Module 3 Floor plan, by author.</td>
</tr>
<tr>
<td>7.23 - 7.28</td>
<td>106</td>
<td>Module 3 Axonometric diagrams, by author.</td>
</tr>
<tr>
<td>7.29</td>
<td>112</td>
<td>Module 4 Floor plan, by author.</td>
</tr>
<tr>
<td>7.30 - 7.35</td>
<td>114</td>
<td>Module 4 Axonometric diagrams, by author.</td>
</tr>
<tr>
<td>7.36</td>
<td>120</td>
<td>Exploded Isometric of moving module, by author.</td>
</tr>
<tr>
<td>7.37</td>
<td>121</td>
<td>Exploded Isometric of smart mirror, by author.</td>
</tr>
<tr>
<td>7.38</td>
<td>122</td>
<td>Diagram of micro-unit transitioning between mode systems, by author.</td>
</tr>
<tr>
<td>7.39</td>
<td>124</td>
<td>360 degree photo sphere of “play mode” micro-unit, by author.</td>
</tr>
<tr>
<td>7.40</td>
<td>126</td>
<td>360 degree photo sphere of “eat mode” micro-unit, by author.</td>
</tr>
<tr>
<td>7.41 - 7.46</td>
<td>128</td>
<td>Images from VR Sphere, by author</td>
</tr>
<tr>
<td>7.47</td>
<td>130</td>
<td>Elevation rendering of Module 1, by author.</td>
</tr>
</tbody>
</table>
This thesis will study the influence of technology on future generations as embodied in the home, the domestic realm and changing habits of dwelling.

a millennial housing typology
Introduction

For this thesis I am interested in a new housing typology based on the laneway house, specific to Toronto’s urban fabric. The thesis will study the influence of technology on future generations as embodied in the home, the domestic realm and changing habits of dwelling. The site, Toronto, was chosen for its growing housing market, and densifying urban landscape. With over 2400 publicly owned laneways, there is potential for new housing in the core of Toronto.4 With the advancement of self driving cars, the need for personal vehicles and car ports will significantly decrease, creating an opportunity to develop laneway housing in its place. Furthermore, the city of Toronto has moved forward with proposed guidelines for future development of laneway housing.5 Case studies based in Vancouver demonstrate its validity and effectiveness to densify the urban landscape and create a pedestrian friendly neighborhood.6 This is a window of opportunity to design housing for the growing population of millennials in the city, and must be thoroughly studied and designed to create a new housing typology for them.

To best understand this thesis, I will be focusing on technological and sociocultural implications. First, social and cultural needs will determine the programmatic requirements of the space; greater usage within certain elements and eliminating programs that may be no longer needed. Program spaces will be redefined based on the changing habits of dwelling. Secondly, technology needs to be accommodated for, to generate designs which are relevant in our modern society. By utilizing space and energy saving elements we can maximize the value of the space to fit within the limited economic means of the millennial generation. Implementing tools such as arduinos to modulate spaces together, in order to create hybrid uses that do not suffer from ambiguity. With further research into the Millennial generation, I hope to develop a foundation on which to design an archetypal home which will suit the needs of the future generation.

A MILLENNIAL HOUSING TYPOLOGY

WHERE

Toronto
- housing boom
- greenbelt act
- condo boom
- foreign investors
- increasing housing cost

WHAT

- generational change in dwelling
- adaptive architecture
- human behaviour
- user input
- smart devices
- smart homes
- artificial intelligence
- automated vehicles
- social media
- laneway housing
- vehicle-less city
- generative design
- urban center
- tranquility of space
- generational wealth
- privacy and security

WHO

- Millennials
- student debt
- diverse demographic
- urban migration
- environmentally conscious
- technology affiliation

- TORONTO
who are the millennials?

Figure 2.1: Traits of Millennials

- 22-37 years of age
- +92 million people
- $3.39 trillion in annual spendings
- ~5.4 hours a day consuming media
The Millennial Generation

The millennial generation\(^7\) has become the largest demographic of consumers in the twenty-first century.\(^8\) Millennials have inherited a different circumstance from the previous generation, dramatically changing the social, cultural, and economic needs of the generation. Most notably, the financial position of post-graduates has become difficult due to the slow economy and rising student debt. While growing concerns of climate change and global warming have significantly affected lifestyle choices. The integration of technology is so embedded in the generation the use of phones, laptops and the internet have redefined the culture and social interactions in modern society. To begin, we will consider the upbringing of the millennial, and the repercussions which have shaped this generation. As they enter the workforce and become influential members of society, it is crucial for architects and designers to understand the thinking and rationale of this generation to design an architecture that is responsive and suited for them.

Generations are identified by people born with similar historical and sociocultural context, thereby encountering similar experiences and commonalities which define the group.\(^9\) "Generational identity is fundamentally rooted in cultural shifts resulting from social, economic, and/or political events or phenomena."\(^10\) For the millennial, the rapidly changing demographic and impact of the 2008 recession are some of these defining characteristics. As digital natives, millennials have grown up alongside technology, and online information.\(^11\) These unique circumstances have led to a different set of values from the previous generations, "ranging from rising distrust of traditional institutions to extreme tolerance for same-sex marriage."\(^12\) This openness and acceptance of previously profound ideologies derives from the diverse demographic of the millennial generation and access to information through the internet. As well, the demographic shift caused by immigration has contributed to "millennials' divergent political philosophies, social views, and policy preferences."\(^13\) Technology has given us the ability to connect to each other, however, it has also further delineated the drastic differences between the previous generation and this one.

\(^7\) Millennial Generation - people born between early 1980s and until 2000
\(^8\) Fry, "Millennials Projected to Overtake Baby Boomers as America’s Largest Generation."
\(^10\) Ibid. 5.
\(^12\) Stella M. Rouse, and Ashley D. Ross, "In The Politics of Millennials: Political Beliefs and Policy Preferences of America’s Most Diverse Generation," Ann Arbor: (University of Michigan Press, 2018), 5.
\(^13\) Ibid. 5.
Figure 2.2: Popular tech companies that use collected data to cater software
Developing with Technology

Millennials have grown up in parallel with the technological boom of the late twentieth century and the start of the information era. This generation can remember a time prior to the internet and smart devices, but are also in tune with the jargon and tools to use technology. If we place Baby Boomers into the pre-digital category, and Gen - Z as post digital, millennials are the only generation who have an understanding of both cultures. As such, their affiliation with traditional values and lifestyles is not fully removed, but the inclusion of digital media must also be embedded to their style of living. As the millennial generation begins to enter the workforce and form a majority in society, how might this mediation between old and new modes of dwelling alter our current understanding of domesticity?

In our increasingly technological age, the internet became its own form of media, developing its own jargon and language. Social networks such as Facebook, Twitter and Instagram have become the channel of self-expression, and values. In part, this has manifested a transition in the cultural ideology from materialistic values as a statement of wealth, to lifestyle and experiential values captured in photos and videos. In an article by Forbes, “since 1987, the share of consumer spending on live experiences and events relative to total U.S. consumer spending increased 70%.” Thus, this increased access to information and exposure to diverse lifestyles could be defined as a change from quantitative to qualitative desires. Established as “trends” or instantaneous socio-cultural norms, they act as economic drivers which have the potential to alter political and commercial decisions. An example from 2018 describes the purge of plastic straws, a movement formed to mitigate environmental waste produced from a single-use item. As popularity from social media grew around this idea, companies were pressured to redesign their straws to remain attractive to consumers. In July 2018, Seattle became the largest city to ban plastic straws with companies such as Starbucks and McDonalds making plans to phase out the plastic tubes by 2020. However, ironically, though the straws have converted to paper or biodegradable materials in many cafes, this one small item does not solve the global issue of plastic waste; this demonstrates the unique way which social media pressure can influence commercial marketing practices.

---

14 Gen - Z, the generation after millennials, born 2001 - present; born into the digital era.
### Context

The thesis will study the influence of technology on future generations as embodied in the home, the domestic realm and changing habits of dwelling.

### AveraGE ANNUAL INCOME AGE 25-34

<table>
<thead>
<tr>
<th>Year</th>
<th>Average Annual Income (Canada)</th>
<th>Average Annual Income (Ontario)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1976</td>
<td>$51,680</td>
<td>$52,560</td>
</tr>
<tr>
<td>2016</td>
<td>$44,300</td>
<td>$46,200</td>
</tr>
</tbody>
</table>

### Percentage of Post-Secondary Graduates

<table>
<thead>
<tr>
<th>Year</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>2016</td>
<td>67%</td>
</tr>
</tbody>
</table>

### Average Student Debt Accumulated

<table>
<thead>
<tr>
<th>Year</th>
<th>Average Student Debt (Canada)</th>
<th>Average Student Debt (Ontario)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1976</td>
<td>$292,518</td>
<td>$334,585</td>
</tr>
<tr>
<td>2016</td>
<td>$490,495</td>
<td>$535,931</td>
</tr>
</tbody>
</table>

### Average Cost of Housing

<table>
<thead>
<tr>
<th>Year</th>
<th>Average Cost (Canada)</th>
<th>Average Cost (Ontario)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1976</td>
<td>$16,000</td>
<td>$210,000</td>
</tr>
<tr>
<td>2016</td>
<td>$490,000</td>
<td>$4,950,000</td>
</tr>
</tbody>
</table>

### Millennial Generation

The next largest consumer generation, to overtake Baby Boomers

### Laneway Housing

Redefining the domestic realm and contemporary dwelling

#### Student Debt

- Increasing housing costs
- Urban cities migration
- Housing boom

#### Mind Map

- Smart living
- Generative design
- Technology

#### Toronto Laneway Housing, A Millennial Housing Typology

Where

- Who
- What
- When

### Table

<table>
<thead>
<tr>
<th>Year</th>
<th>Average Annual Income (Canada)</th>
<th>Average Annual Income (Ontario)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1976</td>
<td>$51,680</td>
<td>$52,560</td>
</tr>
<tr>
<td>2016</td>
<td>$44,300</td>
<td>$46,200</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Year</th>
<th>Average Student Debt (Canada)</th>
<th>Average Student Debt (Ontario)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1976</td>
<td>$292,518</td>
<td>$334,585</td>
</tr>
<tr>
<td>2016</td>
<td>$490,495</td>
<td>$535,931</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Year</th>
<th>Average Cost (Canada)</th>
<th>Average Cost (Ontario)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1976</td>
<td>$16,000</td>
<td>$210,000</td>
</tr>
<tr>
<td>2016</td>
<td>$490,000</td>
<td>$4,950,000</td>
</tr>
</tbody>
</table>

### Time to Obtain a 20% Down Payment

- 5 years
- 13 years
- 16 years
- 20 years
Housing needs and Affordability

Within the past three decades the phenomenon known as "Urban Millennial", a term describing the desire for young people to move into cities, has increased the population within urban centers substantially. As the global population increases to a projected 10 billion by 2050, it is estimated that 70% of the world's population will live in urban areas. However, many of the world's most populated cities including, Hong Kong, New York and San Francisco, are facing a housing crisis where housing costs are hugely inflated. Within the last year, Toronto has moved to 28th place within Bloomberg's Global Housing Cost Index, with Vancouver sitting at 16th. In 2018, the average cost of a home within the Greater Toronto Area cost approximately $750,000, while the average monthly rent for a one bedroom unit cost approximately $2000. According to a report by Paul Kershaw, the average annual income for young adults age 25 - 34, sits at a meager $46,200, granting the millennials the ability to live paycheck to paycheck, but unable to save enough money to purchase a home in the future. Comparing the academic proficiencies of the previous generation, millennials have more than double the number of post-secondary graduates compared to boomers, however, millennials actually earn less when accounting for inflation. The total student debt owed by post-secondary students is quickly rising as the cost of earning a degree climbs each year. Accounting for the average annual income of millennials, it would take 13 years to save up for a 20% down payment for a home in Canada, 16 years in Ontario, and 20 years in Greater Toronto Area. As the cost of housing increases each year, this generation may never save enough to become homeowners. With debt and living costs on the rise, how can the new generation survive under such difficult financial circumstances?

18 Hugh Green, "Smart Cities: How Do We Build the Cities of Tomorrow." (YouTube, 21 May 2013), www.youtube.com/watch?v=YGOvEvm7dm0.
20 CREA, "CREA – Canadian Real Estate Association." CREA. https://www.crea.ca/.
23 Ibid.
With so much focus on the cost of housing, we forget about what kind of housing.

Is there a generational shift in the ideal housing typology?
Often invisible among the younger generation, there has been a shift in the perception of the ideal home and the attributes which define it. This discussion has revolved around the lack of affordable housing, as well as the a reduction of square footage per capita for the younger generation. The “Urban Millennial” concept has proved accurate until recently as millennials have begun to start families.\(^2\)\(^4\) Theorists such as Dowell Myers critique the “tiny home” as an ineffective impromptu to “ideal suburbia” due to affordability\.\(^2\)\(^5\) To grasp the notion of “ideal dwelling”, this thesis first studies the circumstances that formed the ideal of the single-detached home in suburbia and the factors that may contribute to a change in modern forms of dwelling. The question remains, is the popularized suburbia the “ideal” dwelling type for a reason, or is it possibly playing into the elitist perspective where an abundance of space and land size equate to a suitable housing typology? The notion of the suburban dwelling as the ideal housing type has changed within the younger generations due to circumstances such as impending climate change and changes in social behaviours, which have contributed to an evolution in the desired dwelling type.

25 Ibid.
Privacy, Security, Tranquility

Current housing typologies can be rooted in Victorian domesticity, which influenced the attitudes and values embodied in suburban dwellings. The core elements which personify the private home are defined perfectly in the title of Mike Hepworth’s essay, “Privacy, Security and Respectability.” In his essay, he states, “the ‘ideal home’ is an expression of values: the kind of private life that individuals hope to achieve... the ideal home is an essential link between the public and private domestic world... and an effort to achieve normality and respectability by its residents.”

This typology of front yards demarcated by fences and hedges, assured a type of protection from the outside world. In the form of privacy and security cultivated greenery define the boundaries of ownership, separating the harsh outside world from the confines of the safe private home. In parallel, the private interior of the home, its organization of spaces defined by social interaction of the room, became a physical representation of the social status of its dweller. Within the middle-class, the private sphere was “the responsibility of women to create a world free from the dissimulations, manipulations and heartlessness of the outside world.” This established the domestic realm as one of respectability and social performance, oriented around a male-dominated perspective. As such, furnishing and decoration was marketed according to these principles, so that the “successful housewife” could command the domestic realm. This convention of gender roles has long expired in our current society as we move towards a balanced participation in domestic duties.

26 Mike Hepworth, “Privacy, Security and respectability” in Housing and Dwelling: Perspectives on Modern Domestic Architecture, ed. Lane, Barbara Miller, (Routledge, 2007), 150.
27 Ibid., 150.
28 Ibid., 151.
29 Ibid., 152.
30 Karen Halttunen, Confidence Men and Painted Women: A Study of Middle Class Culture in America, 1830-1870. New Haven, Conn.: (Yale University Press, 1982), 59.
31 Mike Hepworth, “Privacy, Security and respectability” in Housing and Dwelling: Perspectives on Modern Domestic Architecture, ed. Lane, Barbara Miller, (Routledge, 2007), 152.
Women don’t leave the Kitchen!

We all know a woman’s place is in the home, cooking a man a delicious meal. But if you are still enjoying the bachelor’s life and don’t have a little miss waiting on you, then come down to Hardee’s for something sloppy and hastily prepared.

Hardee’s
Figure 3.5: Levittown Advertisement, Levittown, 1947 - 1961.
Success and Wealth

The “American Dream” has also long exemplified the pinnacle of happiness and success. This stance revolves around the impression that larger homes represented wealth and class. Based around the nuclear family, mass housing as single-detached dwellings became the prominent typology of post-war suburbia.  

These tiny dwellings were attractive for both developers, (low cost, quickly built, abundant cheap real-estate) as well as consumers, (affordable, large land size, individual ownership) generating the massively coveted typology of the single-detached home. As an extension of the economic benefits of purchasing a home in suburbia during the mid 1900s, suburbs represented an idyllic consumerist lifestyle during this period. The purchasing of domestic products, advertised and propagated through the rise of mass media, created an ideology of success surrounding domesticity and “buying stuff”.

One of the most notable catalysts contributing to the allure of suburbia was the personal automobile and the vehicle oriented city. From the urban scale to the individual home, the function of the suburb was dependent on the vehicle. Cars created the opportunity for dwellings to be farther apart, away from amenities and occupation, which prior, limited the distance dwellings could exist from these programs. This brings us back to the idea of privacy, security and tranquility as desired constructs of the home. Vehicles connected rural dwellings embodying the desired traits of domestic living to convenience, generating what we now know as “urban sprawl” around urban centers. However, suburbia has grown out of proportion, and their negative environmental impact and extreme detachment from the center of the metropolis have led to their disingenuity. The sprawl of low-density, automobile-centric suburbs have also contributed

32 Barbara Miller Lane, Housing and Dwelling: Perspectives on Modern Domestic Architecture. (Routledge, 2007), 272.
33 Ibid.
34 Ibid.
NET ZERO BY 2050: FROM WHETHER TO HOW
ZERO EMISSIONS PATHWAYS TO THE EUROPE WE WANT
SEPTEMBER 2018

Figure 3.7: European Climate Foundation, Net Zero by 2050, September 2018.
to the huge environmental crisis we now know as climate change. There are numerous studies citing the large carbon footprint as a result of energy consumption and vehicle reliance, as well as destruction of natural habitats due to land usage. Though “climate change” is widely accepted in the scientific community as a global emergency, North America as a whole is failing to adjust to, or even accept, the environmental catastrophes we are facing and will face in the near future. A study by Alliance for Market Solution found that 88% of millennials believed climate change is happening, while only around 60% of Americans believe this. As a whole, millennials and younger generations are more worried about the effects of climate change during their lifetimes. A feeling of responsibility towards the environment has begun to manifest itself in the lifestyle choices young people make as consumers; millennials are subverting conventional dwelling habits and long standing traditions. With this in mind, we can ask, does “carbon-bigfoot” suburbia really fit the environmentally-conscious intentions of the younger generation?

37 Ibid.
Urban Millennial Post-Family

Urban millennial responds to and defines the increasing trend for young people to desire to live in urban cities as opposed to suburbs and rural areas. Adam Okulicz-Kozaryn and Rubia R. Valente describe the benefits perfectly as, “cities are safer, offer more and better economic opportunities, afford more chances to make friends or find partners and mates, provide a wide range of amenities, and are more associated with status and ‘making it.’”

The attraction for young adults to dwell in the city is clear, however as the millennial generation ages and begins to start families, there is a shift in desired housing type back to suburbia and the single-detached home. Researchers have begun to notice an increase in millennials moving into suburbia and a decreased number staying in urban cities with their families. Dowell Myers, a demographer at the University of Southern California named this phenomenon “peak millennial”, to describe the stagnation in “urban millennial” numbers. Myers’ position is that young people had only stayed in cities due to lack of affordability in the slow economy. As the economy began to flourish, the young generation could afford to move to the suburbs, leading to the surge in population within suburbs post 2013.

His argument suggests that the suburban dwelling is still the ideal typology because millennials are transitioning back towards it. However, it is clear that this transition in location is not solely from an inherent appeal in suburbia, but rather a lack of suitable housing for families in cities. If a typology existed which filled the void, would millennials still choose a space wasting, carbon producing, waste generating, suburban house?

42 Ibid.
A New Housing Typology

As the millennial generation ages and begins to start families, they are forced to move to suburbia due to the lack of accommodating housing. Being a typology that is so far detached from the demands of the young generation, it should be vehemently refused. Is the idyllic future still only to buy a detached home in the suburb, commute two hours a day to go to work, and manicure an insignificant spot of green grass on the weekends? This notion of materialistic classism has left this generation in form of experiential satisfaction. I believe the “ideal home” in the context of the traditional nuclear family will always situate itself around an economical investment, the privacy of space, and the tranquility of the residential neighborhood. However, housing supporting these three elements does not currently exist within the urban center and suburban housing fails to address the environmental and social values millennials hold. A new typology must be generated to include the basic components of dwelling (wealth, serenity, privacy), while adjusting to the changing and new needs of the Millennial and future generations.

Are we destined for Suburbia?

Potential for Laneway Housing

1. increase density within urban core
2. maintain existing housing type and urban heritage
3. increase walkability with urban center
4. maintain suburban context within urban location
5. investment opportunity for existing owners
6. transition home for families

Figure 4.1: Map of Greater Toronto area, indicating all laneways in the city.
Toronto: Growing Housing, Urban Center, and Home

Toronto is experiencing the largest housing boom – specifically a condo boom – in the history of the city. In the past decade, the city has led in housing construction, with the most high-rise construction for several years. Between 2007-2016, the Canada Mortgage and Housing Corporation (CMHC) estimates that approximately 140,300 new residential dwellings have been constructed. Two factors for the unique condo boom in the city can be related to the Greenbelt act by the liberal party, and foreign interest in the housing market.

The Greenbelt act was formed to protect 7,200 square kilometers of environmentally sensitive agricultural land from development and urban sprawl just north of the city. With a finite range of land available, Toronto's buildable land has become costly to develop. As high -ise towers can occupy more inhabitants on a smaller parcel of land, the construction of condominium towers has been the shift in the housing market. Secondly, in the financial crisis of 2008, Toronto's economy remained healthy, attracting many foreign investors into the housing market. As the market grew, it only attracted more investors due to its large economic potential. However, the growth has generated a housing bubble; housing prices have become too expensive for local inhabitants to afford, as prices are sky rocketed by wealthy investors. This leaves the problem of not only empty apartments but also a housing crisis for city inhabitants due to the lack of affordability.

The city of Toronto acts as ideal prototype for a millennial housing typology due to its diverse population, variety of amenities, and unique potential for a laneway housing type. Toronto contains 2433 laneways, reaching 295 kilometers in the length in total. The neighbourhood of Palmerston will be used in the thesis as the demographic region to start.

---

44 Katy Chey, (Multi-unit Housing in Urban Cities: From 1800 to Present Day), (Routledge, 2018), 318
45 Ibid.
47 Ibid.
Figure 4.2: Drone shot of site, Allen Reynolds Lane
Laneway Housing

The opportunity for economical housing exists in the laneways of Toronto. This housing contains the essential components of privacy, security, and economic potential, while fulfilling the needs of millennials in its location at the urban center. Laneway housing creates a housing densification while maintaining existing housing types and urban heritage. As of 2018, Toronto has added new by-laws to allow for development of this typology.

Toronto’s laneways started in the 1870s as home for stables and workshops. As Toronto densified, the laneway changed into a passage for vehicles as garages filled the back of lots. By definition, “a Laneway suite is a house on the same lot as a detached house, semi-detached house or townhouse, generally located in the rear yard abutting a laneway.” These units are smaller and detached from the host building and replace existing garages or carports designated for the lot. According to the guidelines set by the City of Toronto, the purpose of the Laneway home is to be used as rental units that are subordinate to the principal house. As such, within the current regulations, only individualized suites can be developed by homeowners compared to developing mixed-use or commercial spaces in other cities. As the typology grows and densification increases in Toronto laneways, guidelines will need to be updated to include options for larger mixed-use buildings and commercial spaces to create amenities and programs for the increased population. In addition, it is imperative that incentives pushing for rent control and subsidized housing be generated for individual homeowners to regulate housing cost in the city.

The proposal for laneway homes incites a transformation of the laneway from a vehicle passageway, into a pedestrian one. Cities are advocating for walkability to generate a healthy and environmentally conscious neighborhood. However, as residents take over the laneway, the vehicles are left without a home. In a green utopia, inhabitants would give up their cars for bikes and subways, but with our current lifestyle, this prospect is unlikely. As such, the existing garage is still seen as a necessary component of the domestic realm and improbable to be replaced for additional housing. Be that as it may, the issue of the vehicular home will soon dissipate with the popularization of the self-driving car. Self-driving cars are autonomous vehicles which are capable of carrying passengers without human control. Autonomous cars will drastically alter our current vehicle-oriented metropolises in enormous ways, possibly changing the very core of urban design. This topic in is a thesis on its own, but focusing simply on the aspects of the home, planners propose that as cars start to drive themselves, they no longer need to be parked in garages or curbs. Instead vehicles will drive themselves to a “city nest”, parking stops on the outskirts of cities, and return as needed to retrieve their owners. Looking only at the opportunity left in empty garages, there is huge potential for future development for residential, commercial or green spaces in these leftover slots.

50 Ibid 5.
51 Ibid 14.
53 Ibid,
Figure 4.3 - 4.11: Surrounding Site Photos
Figure 4.12 - 4.20: Laneway Site Photos
Revitalizing the Laneway

Located in the region of Palmerston, the site embodies crucial aspects for ideal city living such as transportation, density, walkability and convenience while also including the three elements of privacy, security and tranquility in its specific neighborhood. The site will focus on the Allan Reynolds Laneway, for its similarity to a suburban crescent and dense population of carports to study. Examining the surrounding site, the neighborhood is filled with commercial, recreational and park spaces. Most importantly, the neighborhood block must contain the amenities not available in the home. Programs such as gyms, workshops, laundromats and parks need to be accessible within a close proximity (walking distance) so that they are no longer necessary in the home. Particular to the design of a millennial home, the programs I hope to remove from a traditional dwelling and instead centralize in the urban fabric are highlighted within the surrounding site.
case studies
Rietveld Schroder House, Gerrit Rietveld 1925.

Designed by Gerrit Rietveld for Truus Schroder, Schroder wanted a simple space free of constraints. Rietveld designed the house to be flexible, using portable partitions to separate rooms.\textsuperscript{54} This allowed for a floor plan with no hierarchical arrangement of rooms.\textsuperscript{55} Children could easily push partitions out to play during the day, and bring them in for privacy.

In addition to this, the Schroder House was designed in accordance to the De Stijl style, demarcated by the bright primary colours and clean horizontal lines.\textsuperscript{56} It represents itself as an icon of the modern architecture movement in its design through its use of space and concepts from the De Stijl movement.\textsuperscript{57} The functionality and design choices of the Schroder House make it a important case study for efficient use of space and functional design. Using portable partitions, Rietveld was able to create an early adaptation of an adjustable space, accommodating to the specific needs of the inhabitants. To take this concept further, we can begin to look at the automation of these wall modules, rather than the manual change in floor space. What would the potential of automated flexible floor plans be in the future of residential architecture?

The Dymaxion House was inspired as a home of the future, incorporating

\textsuperscript{55} Ibid.
\textsuperscript{57} Ibid.
Figure 5.2 (top): Exterior of Dymaxion House
Figure 5.3: Interior of "Wichita House" prototype, from the Dymaxion house
Dymaxion House, Buckminster Fuller, 1933.

innovations in prefabrication and sustainability. Earliest design conceptions by Buckminster Fuller, in the 1920s, it was an early attempt at self-sufficiency and automation within a housing dwelling. To be mass-produced and shipped easily, the Dymaxion House could be seen as Buckminster Fuller’s version of a IKEA furniture as a home. Fuller describes the Dymaxion as:

“the Dymaxion principle of doing ever more with ever less weight, time, and ergs per each given level of functional performance. With an average recycling rate for all metals of 22 years, and with comparable design improvements in performance per pound, ephemeralization means that ever more people are being served at ever higher standards with the same old materials.”

Designed initially as a 100 square meter hexagonal house made of aluminum, the structure was resistant to earthquake and storm. The system revolved around the permanent amenities located at the central pole, allowing for the surrounding interior space to be modular. This created a flexible floor space for inhabitants to design based on their needs. After World War II, the abundance of aluminum allowed Fuller to construct two prototypes in 1946. These were then combined in 1948 into the “Wichita House” transforming its hexagonal shape into a smooth circle. The idea of the Dymaxion house was never completed past its prototype, its attempt at automation within structures are influential in an increasingly automated society. The concepts of prefabrication and mass production within the housing industry are frequently discussed in the future of the architecture industry. With the technology of the twenty-first century, the Dymaxion House may reappear in the architecture future.

59 Richard Buckminster Fuller, Synergetics: Explorations in the Geometry of Thinking. (Macmillan U.a., 1982).
61 ibid.
A Prototype for Adaptable Architecture

To develop a truly millennial architecture, the amalgamation of technology within dwelling is imperative. The concept of technology imbedded with the home is not a new one as smart devices have become an integral part of our society and culture. With the development of devices such as Amazon’s Alexa, and the Google Home, the interest in integrating technology into buildings is growing faster as more and more smart home devices are being designed and sold. However, smart home devices are being integrated as attachments to the home, rather than being designed and thought-out as part of the architecture from the beginning. How can we combine technology and architecture to produce a modern home?

To develop this concept of a technological architecture, the proposal for an “intelligent space” a prototype was required. Together with partner Suvik Patel and Professor Steven Beites, we developed a model using our own collected data from arduino modules, and generated dynamic floor plans that responded to the specific needs of the user. This research serves as a framework for adaptable, intelligent spaces to be a part of the future of dwelling in the millennial generation.
This project sought to investigate how architecture and artificial intelligence can be combined to generate an intelligent building typology unique to its user. The investigation revolves around different types of sensors and building an installation that can move and react based on its interactor. Our main focus is the potential to change the floorplan of a space throughout the day for the benefit of its user. While homes today consist of static walls and a fixed floor plan, we want to explore interior spaces that adapt to its inhabitants rather than the inhabitant having to adapt to the space. How can dwelling spaces evolve and adapt alongside its inhabitants? With this data, we will be proposing a new floorplan that changes throughout the day to better enhance the way we interact and move throughout the space. This will be done with the walls and objects of the space being able to move freely and reorganize itself to better accommodate the user. The end result will be an intelligent space that changes throughout the day in accordance to the schedule and habits of its user.
One of the defining trends of the 21st century is the population growth. More specifically, the rapid population growth in dense urban cities. In the 1800’s, 3% of the world’s population were urban dwellers which later increased to 14% in the 1900’s and 30% in 1950.62 By 2008, we had already surpassed the historic mile mark and became 50% urban and by the year 2050, it is projected to be as high as 70% as the world population increases to 10 billion people.63 We are slowly becoming an urban world as people are migrating from rural to dense urban cities.

Specifically looking at Ontario, and Toronto, housing cost has increased by almost double, with cost in the G.T.A being three times as much. As the footprint of the home inevitably grows smaller, architects must find a way to design livable and comfortable spaces within these tight parameters.

Technology has quickly become an integral element of our current modern society. Today, smart phones, and laptop computers are used everywhere and we spend an average of 5.4 hours a day consuming media off these devices.64 The integration of technology into buildings is growing with the development of “Smart Home” devices such as Google Home, and Amazon’s Alexa. As these devices become popularized, they mark the first attempt at integrating technology within architecture. However, smart home devices are being integrated as attachments to the home, rather than being design and thought

---

62 Hugh Green, ‘Smart Cities: How Do We Build the Cities of Tomorrow.’ YouTube, 21 May 2013, www.youtube.com/watch?v=YGOVEvm7dm0.
63 Ibid.
out as part of the architecture from the beginning. Though these gadgets are fun and unique, they lack true integration with the homes they inhabit. Furthermore, the limiting factor of these devices is the required input from the user in order to create a response in the environment. As technology advances towards machine learning, is it possible that artificial intelligence can begin to respond to the human occupants, and adapt to their behaviours?

Utilizing similar components of sensors tracking devices, how can we employ tools such as arduinos to create a better environment for its user? To design a truly smart home, or intelligent space, the architecture should be able to react according to the users’ collected data based on the occupants’ habits and schedule, but as well the physical properties and limitations of the space. In our proposal, we consider the participants within the dwelling, temperature, and atmosphere of space, noise levels, and light ambience. This data will serve as a base to understand the living habits of the dweller. By comparing the data and cross analyzing the parameters, we can begin to recognize trends within the data set, informing the patterns and mannerism within a day cycle. Next, an adjusting floor plan can be generated based on the input data of the occupant which informs the output change in walls and objects. Lastly, using generative design and machine learning, we can develop a set of parameters to bring about the optimum design layout based on the users needs.
module 1: common area & kitchen
module 2: theo’s room
module 3: suvik’s room

Figure 6.3: Floor plan of apartment and testing space
To start our analysis, we used our own apartment as a testing ground for data analysis. Three Arduino clusters are setup collecting data from each individual. Figure 4 represents the floor plan of our apartment, indicating the three modules we created for data collection. Module 1 is located in the common area and kitchen, and modules 2 and 3 are located within our individual rooms. The resulting information creates a framework from which to generate an adjustable floor plan, designed for the user.

Arduino Module

Using circuito.io, we were able to generate an example of the Arduino module we would need to fit all our sensors. The tool generates a simple diagram to follow to make the connection of sensors simple. We used this setup for all three of our Arduino modules placed in the various rooms. Not represented is the data logging shield which is placed directly on top of the Arduino, and the external battery banks we used to power the Arduinos.

Arduino Setup

Figure 6.4: Arduino module visualized from circuito.io enabled a simple guide to construct our module.

---

To start our analysis, we used our own apartment as a testing ground for data analysis. Three Arduino clusters are setup collecting data from each individual. Figure 4 represents the floor plan of our apartment, indicating the three modules we created for data collection. Module 1 is located in the common area and kitchen, and modules 2 and 3 are located within our individual rooms. The resulting information creates a framework from which to generate an adjustable floor plan, designed for the user.

Arduino Module

Using circuito.io, we were able to generate an example of the Arduino module we would need to fit all our sensors. The tool generates a simple diagram to follow to make the connection of sensors simple. We used this setup for all three of our Arduino modules placed in the various rooms. Not represented is the data logging shield which is placed directly on top of the Arduino, and the external battery banks we used to power the Arduinos.

---

To start our analysis, we used our own apartment as a testing ground for data analysis. Three Arduino clusters are setup collecting data from each individual. Figure 4 represents the floor plan of our apartment, indicating the three modules we created for data collection. Module 1 is located in the common area and kitchen, and modules 2 and 3 are located within our individual rooms. The resulting information creates a framework from which to generate an adjustable floor plan, designed for the user.

Arduino Module

Using circuito.io, we were able to generate an example of the Arduino module we would need to fit all our sensors. The tool generates a simple diagram to follow to make the connection of sensors simple. We used this setup for all three of our Arduino modules placed in the various rooms. Not represented is the data logging shield which is placed directly on top of the Arduino, and the external battery banks we used to power the Arduinos.

---

Figure 6.5: Prototype 1 consisting of a temperature / humidity sensor, PIR motion sensor and a light sensor.
Prototype 1

Situated on our island bridging the kitchen and the common space, this prototype failed to measure occupancy as the PIR motion sensor was only able to detect active motion. The data logging shield also failed to accurately record time and date of the entries resulting in inaccurate data. Furthermore, powering the Arduino through a 9v battery caused issues with the RTC data logging shield not receiving enough power to operate.

In our next prototype, a sound sensor was added to detect the amount of sound in the space to determine how many people were occupying the space. An additional PIR motion sensors were also added to measure the activity in both the common and kitchen spaces. Furthermore, a manual switch was added that would track the occupancy in the space along with an LED to let the inhabitant know which position the switch was in.
Figure 6.7: Module 1 consisting of 2 PIR motion sensor, light sensor, sound sensor, temperature / humidity sensor and a manual occupancy switch with an LED.
Module 1: Kitchen & Common Space

Building upon our prototype 1, this iteration successfully measured and recorded the activity in the cooking and common area through the incorporation of two PIR motion sensors. Furthermore, through the implementation of a temperature and humidity sensor, we were able to keep track of the highs and lows of the temperature fluctuation throughout the day to accurately determine which each occupant preferred their space. Alongside, a light sensor was implemented to be able to perceive the amount of natural and artificial light filled the space throughout the day which aided us determine the amount of sunlight the space was exposed to and how it can benefit us in naturally heating the space during the times we occupied it.

Lastly, through the manual incorporation of a switch alongside an LED, we were able to accurately perceive when we were occupying the space during the day which would later help us to determine when the space needed to be expanded for use.
Figure 6.9: Module 2 consisting of a PIR motion sensor, light sensor, sound sensor, temperature / humidity sensor and a manual occupancy switch with an LED.
Module 2: Theo’s Room

Moving away from the common space, as Theo’s and Suvik’s room are almost identical, we tried to place the modules in the same spots so we would have accurate data measurements. This module was placed in front of the window to monitor both the amount of natural light and artificial light in the room which we would later cross reference with the occupancy data to determine how much brightness Theo prefers his space during what time of the day. While the common / kitchen space had two PIR motion sensors, we decided to proceed with only one sensor in our rooms to monitor our desk activity as it is where we spend most of our time.

As we had a heater and an AC in both of our rooms to regulate the temperature, a temperature and humidity sensor was able to monitor how warm or cool Theo preferred his living space to be. Running into the same problem as the common space, the sound sensor unfortunately, was not able to accurately output the data as we had issues collaborating the threshold level. Finally, through the same set up as the common space, a manual switch kept track of when Theo was occupying the space.
Figure 6.11: Module 3 consisting of a PIR motion sensor, light sensor, sound sensor, temperature / humidity sensor and a manual occupancy switch with an LED.
Module 3: Suvik’s Room

Lastly, just like Theo’s room, the placement of the module was also in front of the window for Suvik’s room. Unlike Theo’s room however, the PIR motion sensor tracked both the desk activity and the bed activity as the placement of his desk was in such a way where it provided no natural sunlight and so a compromise had to be made. The temperature and the humidity sensor served the same purpose as Theo’s room as well as the light sensor although the data collected from these sensors were drastically different. For Suvik’s room, the sound sensor was able to accurately detect the sound level but it served no real purpose as we had no data to compare it to as the other two spaces was no able to successfully record the sound data. Finally, through the same set up as both the common space and Theo’s room, a manual switch kept track of when Suvik was occupying the space.
Figure 6.13: Excel data visualized into graphs based on time frames
The data was first represented using simple line graphs to understand the changes between spaces and time. The three graphs analyze light, temperature and humidity in comparison to the other rooms. We can begin to see the patterns in relation to occupancy.
Figure 6.14: Occupancy data visualized in a 24 hour cycle

**Occupancy Graph**
Looking at the occupancy data of a single day we begin to understand the schedule of the user. Here we begin to understand when a person is using a space and when they may be preparing a meal. We can see a gap between 1:30 pm until 4:30 pm signifying the class time where both occupants would be removed from the house. However we also begin to see a problem in the dataset with more than two occupants.
Figure 6.15: multiple variable compared against separate rooms and occupancies.
By overlapping the data, it was easier for us to visualize and compare the temperature, humidity and motion sensor data. As the common / kitchen area was usually always heated or cooled naturally, it stayed relatively ideal temperatures. However, it was clear that Suvik preferred his room much warmer compares to Theo but the humidity was higher in Theo’s room. In terms of the motion sensor, as Suvik’s room was tracking both the motion on his bed and his desk, it didn’t make sense to compare it to Theo’s as his was only tracking his desk.
Since we were living with a third roommate, the floor plan we currently had of our apartment was inaccurate compared to the data we were collecting as the data was only from two people. We decided to remove one of the bedrooms resulting in a much smaller floor plan with the kitchen and living room positioned side by side while Theo's and Suvik's bedrooms were laid out vertically retaining the position of the windows. While the theoretical floor plan had a much smaller common / kitchen space, we could still use the data we collected to create a transforming floor plan.

Figure 6.16: existing floor plan converted to theoretical floor plan to use for prototype

Revised Floor plan
Revised Floor plan

We were then able to determine the static and moving components of the theoretical floor plan that we wanted to alter depending on the data we had recorded. Depending on the time of the day, we envisioned the three spaces to reconfiguring itself by expanding or shrinking based on various sensor data we had collected. Couch, kitchen island, wall partition separating Suvik and Theo’s room, wall partition separating the rooms from the common and kitchen spaces.

Static component consist of:

- Kitchen counter, Washroom, Closet spaces in either rooms.

Moving components consist of:

- Couch, Kitchen Island, Wall partition separating Suvik and Theo’s room, Wall partition separating the rooms from the common and kitchen spaces.

Figure 6.17: Existing floor plan converted to theoretical floor plan to use for prototype
Figure 6.18: screen capture of grasshopper definition used to generate moving floor plan

grasshopper definition
Using Grasshopper we created a definition that would read the excel data, and use the variables to adjust the moving elements of our new floor plan. These parameters were set using defined max and min, which we chose as the smallest space needed to maintain the static objects within the space. This prototype serves as an initial concept of how a moving floor plan can adapt to its user.
Test 1

Though natural light has no correlation to occupancy, if there is no occupancy in a specific room, adjustments can be made for more natural light in occupied spaces. In this test, we used the variables of ambient light within the room, as well as occupancy in individual rooms, to prompt the changing floor areas to increase and decrease in response to these variables. If an individual room is not occupied, the adjacent room increases its floor area to take advantage of the natural lighting.
Figure 6.19: Test 1 floor plans changing each hour based on the input data (light, occupancy) to maximize lighting for individual occupancy.
Test 2

Adjusting to occupancy of shared rooms, the spaces change according to the usage data. Floor area changes to occupy the shared space when not occupied. We begin to indicate square footage in each room. This test reads the occupancy of shared and individual spaces and adjusts the floor area in response to unoccupied spaces to maximize the usage of the space. In addition to wall elements changing, furniture is considered as well to further develop this idea of adaptable spaces.

shared occupancy
Figure 6.20: Test 2 floor plans changing each hour based on the input data (individual occupancy, shared occupancy) to maximize floor area for individual and shared spaces.
Conclusion

During our experimentation, we faced many roadblocks which made the progression of our study very difficult. These problems can be categorized into 3 factors: hardware issue, lack of technical skills and external factors.

Hardware

The arduino sensors suffer from intricacy of its components. For example the sound sensor which we used was only binary, and the threshold was unable to give an accurate reading. The data set collected was not used due to the inaccuracy of the data. Furthermore, a different sensor for measuring occupancy would be more suitable, such as the Panasonic Grid-eye, due to the inability to track non-moving occupants. Our makeshift occupancy switch lacked automation and added an element of human error in the likely event that an occupant forget to press the switch.

Lack of Technical Skills

In utilizing the arduino uno and sensors, there were many new programs that we had to learn in order to access and manipulate the data we accumulated. This included setting up the physical sensors, coding the arduino to function and using grasshopper and firefly plug-ins to transform the data.

External Factors

A significant problem with our analysis is the data collection of the common spaces. As our apartment currently has four occupants, the additional occupants trigger the sensors, giving an inaccurate reading.

Next Steps

This initial prototype has succeeded in representing a movable floor plan that can adapt based on user data collected from sensors. Although the results are still preliminary and simple, it succeeds in demonstrating the potential of intelligent spaces in the future.
Bibliography


Green, Hugh. *Smart Cities: How Do We Build the Cities of Tomorrow.* YouTube, 21 May 2013, www.youtube.com/watch?v=YGOVEvm7dm0


a prototype for millennial housing

Figure 7.1: Laneway rendering
a prototype for millennial housing
Situated in the laneways of Toronto, the contemporary dwelling for millennials will begin to manifest. By defining the current dwelling spaces within existing domestic realms, we can understand their use and necessity to contemporary living. The cost per square foot within the city and the environmental impact of larger homes have led to a design that minimizes the overall floor area of the domestic realm. The living spaces must be prioritized to keep the essential elements of dwelling, based on the needs and requirements of the new generation. By using a modular floor plan, similar programs can be combined to use the same floor area, while acting as two separate dwellings, as represented in intelligent spaces. Finally, to place the structure in the laneway typology, the surrounding site and landscape should be accounted for to develop a cohesive architecture.

When we compare the needs of the urban dwelling to the suburban we are familiar with, many of the programs and amenities within the suburban home are dispersed in the urban fabric of the city. Components such as storage, laundry, recreation and work space which inhabit the residual spaces in garages and basements are no longer necessary because they become easily accessible in the urban city. Amenities such as coin laundry and storage units have been embedded within the fabric of cities with newer services such as bike shares constantly being developed to bring traditional domestic realms to contemporary community services.

To the suburban dweller, these residual spaces seem crucial to the basic habits of dwelling. However, it is important to understand a generational transition between baby boomers and millennials. It is no longer necessary to amass excessive goods and equipment if these tools can be accessed in the community. As condominium suites accumulate, businesses have seen the need for these programs within the community. This has led to the development of new organizations such as co-working spaces for freelancers, mil workshops to build and craft, and community gardens to grow local food. Comfortable access to these programs release the need for redundancy in the home. Therefore spaces such as the garage, commonly used as a workshop, or basements mostly used for storage are no longer required in contemporary dwelling. When supplementary domestic realms are removed and placed within the neighborhood, our tools are more effectively used, cost is minimized and dispersed, and these programs become gathering spaces for interacting and collaborating.

In spite of the criticism of suburban dwellings, existing urban dwellings are likewise far from ideal. In addition to the growing cost yet shrinking floor area, an abiding factor of condominium and apartment units is the lack of access to natural spaces. “Research in environmental psychology suggests that people's desire for contact with nature serves an important adaptive function, namely, psychological restoration.”

The importance of landscaped areas within urban society offer environmental, economic, and social advantages, but furthermore, they offer psychological benefits to inhabitants and dwellers surrounding them. Similarly, shared outdoor spaces such parks, gardens and playgrounds are important community spaces boosting the psychological health of the neighborhood. Although cities are beginning to push for more public landscapes, the option for private outdoor space is limited due to the cost of land.

Returning to Dowell Myers' position of peak millennials, I hypothesize that millennials were returning to the suburbs due to the lack of suitable housing supporting the basic components of dwelling within the city. The availability of private, outdoor space is a critical feature desired in the ideal home, but it cannot be found presently in obtainable urban housing. As modern society has matured in suburbia, the aspects of independent, natural landscape in the form of patios, decks and backyards have become embedded in our domestic psyches. This type of space is not to be confused with undefined patches of green grass and empty lawns, what is desired is external activity space that is designed with a program. These spaces could take the form of swimming pools, outdoor fireplace, lounge patio or playground, but are relevant as an addition to the ideal home as a mode of psychological relaxation and connection with the natural environment.

This thesis imagines four different housing types, that will reflect the different stages of a millennial life. These units will reflect the lifestyle and spatial needs of the user, incorporating technological elements of “intelligent spaces” that are well suited to the technological generation. There are many challenges of designing within the parameters of the laneway home to include all the necessary elements of a successful millennial home. First, the orientation and typology of laneway houses limit the orientation of glazing and access to natural light. Windows in the units are strategically placed to maximize the amount of natural light entering the home while, maintaining privacy along the laneway and abuting host building. The restricted floor area pushes for an efficient floor plan to maximize every inch of the available area. Lastly, to embed an adaptable architecture into the design, dynamic furniture units are designed to fit the many needs of the occupants.

In order to simplify the transitions between furniture and wall modules, I have defined the different types of domestic programs into five modes. These modes

clarify the domestic activities contained within a home into eat, sleep, groom, dress and play. Eat mode represents the systems and activities required to consume and cook food. Sleep mode generates furniture for rest and relaxation. Groom mode encompasses the necessary equipment for cleaning the body and home. Dress mode highlights storage spaces required for a multi-seasonal living. Finally, play mode represents the changes to create a space for recreation and activity in an indoor context. As inhabitants transition throughout their day, the home occupies a different mode to adapt to the users' specific needs. As each of the four designs are explored, the modifications of five modes will be represented in the design of furniture and wall systems.
micro lot type:
- single lot host occupancy
- long buildable area from setback
- 4 meter height maximum
- 10 meter maximum length
- ideal for micro unit

small lot type:
- single lot host occupancy
- increased setback distance
- 6 meter height maximum
- approx. length 7.5 m
- ideal for bachelor unit

medium lot type:
- double lot host occupancy
- 5 meter setback distance
- 6 meter height maximum
- approx. length 7.5 m
- ideal for single family unit

large lot type:
- multi lot host occupancy
- 5 meter setback distance
- 6 meter height maximum
- approx. length 5 meters
- ideal for multi-generational family/ multi-unit dwelling

Figure 7.3: Defining programs based on lot parameters
Figure 7.4: Lot types based on lot sizes

As of 2018, new regulations have been added to allow for the construction of Laneway homes in the laneways of Toronto. These by-laws dictate the overall size and orientation of possible addition based on setback distances in reference to the existing building. As such, the resulting size of the potential laneway house is determined based on its “host occupancy”. Limitations include a 10 meter maximum depth, 6 meter maximum height and a 5 - 7.5 meter setback from the existing dwelling based on the height of the new structure. This led to a variety of potential building sizes on the site which were then separated into 4 categories, micro, small, medium and large lot sizes. The four lot sizes were determined based on the potential lifestyles a millennial might transition through, from a single bachelor, to starting a family, into a multi generational home.
micro unit
The micro unit occupies one quarter of the small lot type along the laneway. The smaller host building allows for the two units to be abutted against each other, with access to the coming from the backyard entrance beside the host building.

single unit
The single unit shares the small lot type with the micro unit or single unit. Access from the front and back entrance create a street front presence and separate terrace shared with the host building. Both the single and micro units are able to be deeper in depth due to the depth of the existing building but shorter in height to minimize blocking of views and natural sunlight for the host occupants.

Figure 7.5: Site plan
family unit

Within the medium sized lot type, the family unit is best suited to make use of the taller building height but shorter building depth. Since the host building occupies two lots for its single building, the outdoor space is larger, creating an expansive play space for play and activities. Placing the building 4 feet underground, the unit is more private while allowing for allowing for natural sunlight with windows.

multi-generational unit

The multi-generational dwelling occupies the largest lots where the host building covers 3 or more lot zones. As the host building is much larger, the resulting laneway structure is shallow and wide, allowing for a larger facade for glazing, resulting in more possible bedrooms.
micro unit
ideal for single occupancy
building footprint = 195 ft²
archetypal footprint = 305 ft²
height = 13 ft
length = 16.5 ft

single unit
ideal for single occupancy
building footprint = 400 ft²
archetypal footprint = 520 ft²
height = 13 ft
length = 33 ft

Figure 7.7: Section cut through site
family unit
ideal for young families
building footprint = 718 ft²
archetypal footprint = 922 ft²
height = 16 ft
length = 26.5 ft

multi-generational unit
ideal for students/ large family
wheelchair accessible ground floor
building footprint = 1270 ft²
archetypal footprint = 1635 ft²
height = 16 ft
length = 18 ft x 35 ft
Figure 7.8: Module 1 Floorplan
The first unit, the micro-unit, occupies a quarter of single host lot. Incorporating the ideals of intelligent spaces, the floor plan of the unit changes based on the specific needs of the user. This unit is designed for a single occupant student or young professional who requires less space. The design aims to create a comfortable home within the smallest possible form factor, without compromising domestic dwelling spaces. In this process, inhabitants do not have to compromise on necessary equipment and tools which would normally be removed or reduced to conserve space in smaller units. The proposed area and static floor area compare the physical footprint of the unit to its potential floor area. Therefore, although the unit is only 195 square feet, it has the accommodations of a unit with 305 square feet. This is possible because of the dynamic furniture components of the design which allow the architecture to autonomously adapt to the users needs. In the micro unit, this is controlled by a central shelf module that acts as an entertainment unit and kitchen island. The simple layout of the floor plan merges circulation with floor space, while maintaining a place for storage.

Module 1: Micro Unit
micro unit
ideal for single occupancy
building footprint = 195 ft²
archetypal footprint = 305 ft²
height = 13 ft
length = 16.5 ft

eat
Center module moves to center of room to create an island for food prep and dining. A full-sized oven and pantry create a full kitchen within the limited footprint.

sleep
Center module moves against kitchen counter to reveal monitor. Murphy bed drops down to reveal a double bed for rest.

groom
The small bathroom is illuminated with a skylight. Each unit is equipped with a personal washer and dryer, simulating larger amenities within a small unit.

dress
Small units often lack closet space, as they represent static pieces that occupy substantial area. An efficient layout allows for plenty of storage space for each season.

play
Center module moves against kitchen counter to reveal monitor. A clear space in the center of the room is revealed for recreation and play.

Figure 7.9 - 7.14: Module 1 Isometric diagrams
**eat**

Center module moves to center of room to create an island for food prep and dining. A full-sized oven and pantry create a full kitchen within the limited footprint.
Center module moves against kitchen counter to reveal monitor. Murphy bed drops down to reveal a double bed for rest.
The small bathroom is illuminated with a skylight. Each unit is equipped with a personal washer and dryer, simulating larger amenities within a small unit.
Small units often lack closet space, as they represent static pieces that occupy substantial area. An efficient layout allows for plenty of storage space for each season.
Center module moves against kitchen counter to reveal monitor. A clear space in the center of the room is revealed for recreation and play.
Figure 7.15: Module 2 Floor plan
Prototype 2, the single unit dwelling occupies half the single lot, and contains a private bedroom looking out to a shared backyard. This unit is ideal for single or double occupancy, and includes a workspace, sliding out kitchen table, and second full bed. The design intention was for working professionals or couples. The physical area of the unit is 400 square feet but has a potential area of 520 square feet. More examples of moving modules are represented here such as a monitor module that rotates down to become a large dining table, as well as two murphy beds that appear from the walls in sleep mode. The layout of the floorplan uses the kitchen as the circulation space, while converting a traditional living room to a separate bedroom for guest.
Figure 7.16 - 7.21: Module 2 Axonometric diagrams
The kitchen is located at the center of the unit, spanning the corridor space. A island table is available for individual dining as well as a mobile unit capable of rotating to become a dining table suitable for six guests.
The bed appears from the wall in the main bedroom in order to maximize floor space. Additionally, a second bed can come out of the living space for guest.
dress

A closet module in the bedroom conceals the bed to reveal a hidden closet. Within the confined space, storage for multi-season attire is important in northern climates.
The small bathroom is hidden behind the bed module. Its placement at the center of the floor plan allows for the bedroom and living space to freely move and change based on the user.
play

Parallel to the closet, a sliding door reveals a work desk for study. The living room module can rotate upright to be used as a television monitor.
Figure 7.22: Module 3 Floor plan
Module 3: Single Family Unit

The single family dwelling occupies the medium size lots. The building is planted four feet into the ground to create taller ceiling heights for the first and second floor. Similar to the single unit, the family utilizes the monitor/dining table, closet module, and sliding island. Entering the unit, inhabitants are faced open stairs to the ground and second level. Adjacent, a long kitchen with a pull out table serves as an countertop cooking and eating. Bathrooms are centralized and aligned for efficiency. Bedrooms and entertainment spaces are placed at the ends the building to maximize natural lighting and views toward the street. This unit was designed to accommodate millennials starting a family, with lots of potential for play outdoors, being close to the downtown for work, while embracing the ambiance of the peaceful neighborhood.
Figure 7.23 - 7.28: Module 3 Axonometric diagrams
A small table slides out from the wall for additional space for food prep and dining. In addition, a module in the living space rotates to become a dining table.
The bed appears from the floor in both bedrooms in order to maximize floor space. Additionally, a second bed can come out of the living space for guests.
dress
A large expansion of closets reveal themselves in master bedroom to accommodate for multi-season attire. Closet space near the front and back entrance allow for access from either ends.
The small washroom is hidden underneath the staircase. A shared bathroom is centered on the second level accommodating both bedrooms.

groom
The small washroom is hidden underneath the staircase. A shared bathroom is centered on the second level accommodating both bedrooms.
play
Disappearing modules in both bedrooms create open space for exercise, work or play. The users needs will determine the specific program of the space.
Figure 7.29: Module 4 Floor plan
Lastly, prototype four sits on the large lot types, and is designed for a multi-generational family. The first floor is wheelchair accessible, with a large bathroom, and bedroom to allow for free travel on ground level. Sharing a large outdoor space spanning multiple lots, the back of the multi-generational home maximizes natural light and views to the shared landscape. The open space layout supports different room orientations, with retracting beds in every room to make use of even smaller spaces. The multi-unit dwelling creates a comfortable dwelling space for multiple generations to work and play, a shift towards a more sustainable lifestyle.

Module 4: Multi-unit Dwelling
**ideal for single occupancy**

- **building footprint = 195 ft²**
- **archetypal footprint = 305 ft²**
- **height = 13 ft**
- **length = 16.5 ft**

**eat**

- Center module moves to center of room to create an island for food prep and dining. A full-sized oven and pantry create a full kitchen within the limited footprint.

**sleep**

- Center module moves against kitchen counter to reveal monitor. A Murphy bed drops down to reveal a double bed for rest.

**groom**

- The small bathroom is illuminated with a skylight. Each unit is equipped with a personal washer and dryer, simulating larger amenities within a small unit.

**dress**

- Small units often lack closet space, as they represent static pieces that occupy substantial area. An efficient layout allows for plenty of storage space for each season.

**play**

- Center module moves against kitchen counter to reveal monitor. A clear space in the center of the room is revealed for recreation and play.
micro unit
ideal for single occupancy
building footprint = 195 ft²
archetypal footprint = 305 ft²
height = 13 ft
length = 16.5 ft

eat
Center module moves to center of room to create an island for food prep and dining. A full-sized oven and pantry create a full kitchen within the limited footprint.

groom
The small bathroom is illuminated with a skylight. Each unit is equipped with a personal washer and dryer, simulating larger amenities within a small unit.

dress
Small units often lack closet space, as they represent static pieces that occupy substantial area. An efficient layout allows for plenty of storage space for each season.

play
Center module moves against kitchen counter to reveal monitor. A clear space in the center of the room is revealed for recreation and play.
micro unit ideal for single occupancy
building footprint = 195 ft²
archetypal footprint = 305 ft²
height = 13 ft
length = 16.5 ft
eat
Center module moves to center of room to create an island for food prep and dining. A full-sized oven and pantry create a full kitchen within the limited footprint.
sleep
Center module moves against kitchen counter to reveal monitor. Murphy bed drops down to reveal a double bed for rest.
groom
The small bathroom is illuminated with a skylight. Each unit is equipped with a personal washer and dryer, simulating larger amenities within a small unit.
dress
Small units often lack closet space, as they represent static pieces that occupy substantial area. An efficient layout allows for plenty of storage space for each season.
play
Center module moves against kitchen counter to reveal monitor. A clear space in the center of the room is revealed for recreation and play.
ideal for single occupancy
building footprint = 195 ft²
archetypal footprint = 305 ft²
height = 13 ft
length = 16.5 ft
eat
Center module moves to center of room to create an island for food prep and dining. A full-sized oven and pantry create a full kitchen within the limited footprint.
sleep
Center module moves against kitchen counter to reveal monitor. Murphy bed drops down to reveal a double bed for rest.
groom
The small bathroom is illuminated with a skylight. Each unit is equipped with a personal washer and dryer, simulating larger amenities within a small unit.
dress
Small units often lack closet space, as they represent static pieces that occupy substantial area. An efficient layout allows for plenty of storage space for each season.
play
Center module moves against kitchen counter to reveal monitor. A clear space in the center of the room is revealed for recreation and play.
EAT
Center module moves to center of room to create an island for food prep and dining. A full-sized oven and pantry create a full kitchen within the limited footprint.

SLEEP
Center module moves against kitchen counter to reveal monitor. Murphy bed drops down to reveal a double bed for rest.

GROOM
The small bathroom is illuminated with a skylight. Each unit is equipped with a personal washer and dryer, simulating larger amenities within a small unit.

DRESS
Small units often lack closet space, as they represent static pieces that occupy substantial area. An efficient layout allows for plenty of storage space for each season.

PLAY
Center module moves against kitchen counter to reveal monitor. A clear space in the center of the room is revealed for recreation and play.
Figure 7.36: Exploded Isometric of moving module

- wood shelf
- plastic cap
- metal support beam
- stone back table
- glass monitor
- rotating gear
- table stepper motor
- monitor wiring
- wheel
- wheel axle
- wheel bearing
- wheel gear
- stepper gear
- stepper motor
- arduino sensors
- arduino
- control board
- computer board
- support plate
- small stool

technology and architecture
To develop a truly millennial architecture, the amalgamation of technology within dwelling is imperative. The concept of technology embedded with the home is not a new one, as smart devices have become an integral part of our society and culture. However, smart home devices are being integrated as attachments to the home, rather than being designed and thought-out as part of the architecture from the beginning. How can architecture and technology be combined to produce a modern home?

To develop the concept of a technological architecture, a prototype was created using our own collected data from arduino modules, and was used to generate dynamic floor plans that responded to the specific needs of the user. This research serves to form the framework for adaptable, intelligent spaces integrating technology and space planning in the future of architecture.
Figure 7.38: Diagram of micro-unit transitioning between mode systems
New innovations in technology have allowed architectural representation to evolve within the past few decades. Photo-realism in digitally produced renderings have become a vital tool for architects to represent their designs to clients and the public. However, as technology constantly improves, new means of representation are being developed, replacing their predecessors. As of 2018, 52% of media viewed was through mobile devices with the percentage growing yearly. The interest in virtual reality has also sparked a new method of visualizing space within the field. To remain relevant in our evolving time, it is crucial that architects and designers stay up to date with the newest design softwares.

It is imperative for a millennial housing type to be represented in a millennial methodology. Two 360 degree renders, or photo spheres, were generated for viewing on mobile devices, as well virtual reality headsets based on the micro-unit. These renderings allow for a 3D perspective in exploring space, compared to traditional 2-dimensional renderings. Viewers can delve into the different modes, as well as visualize the details of space, moving their head, in a natural form of exploration. In addition, sound becomes a factor in adding a new sense to interacting with architecture, creating an environment where we can see and hear the spaces we envision.

To see the images on a mobile device, access the site: https://data.sentiovr.com/spaces/5297/space_1554342532/vtour/tour.html?fbclid=IwAR1nIWQTGu5sFeEFBcHlyhyzYdHAdOovTa0XMODuDC0s4NjeNh9Q5ybBDU

What is the future of architecture representation?
Figure 7.39: 360 degree photo sphere of "play mode" micro-unit
Figure 7.40: 360 degree photo sphere of “eat mode” micro-unit
Figure 7.41 - 7.46: Images from VR Sphere
A millennial housing type is one which integrates technology, socio-cultural elements of dwelling, and a tangible economic investment together to reflect the needs of the next generation. In examining the history of domesticity and suburbia, we can re-evaluate the essential values of dwelling and remove what is no longer necessary for a productive and sustainable future. The laneway poses as an ideal site for the millennial generation by connecting suburban principles of domesticity to the socio-cultural values of a fast-paced generation. Technology being rooted in the daily lives of millennials, should be integrated into the housing of the future. The development of intelligent spaces, utilizing furniture and wall modules to adapt to users, innovate housing beyond smart home devices. Using four separate design prototypes, the buildings can be catered to the specific stages of life in a millennial lifetime, while the five different modes allow for architecture to adapt to the needs and habits of a millennial's daily life. In our constantly developing generation, it is imperative that architecture utilizes innovative technology to create a better future in the homes of the next generation.

Conclusion

Figure 7.47: Elevation rendering of Module 1
Bibliography


Gallup, Inc. “Global Warming Concern Steady Despite Some Partisan Shifts.”
Bibliography


Hepworth, Mike, “Privacy, Security and respectability” in Housing and Dwelling: Perspectives on Modern Domestic Architecture, ed. Lane, Barbara Miller, Routledge, 2007,152


Bibliography


a millennial housing typology