

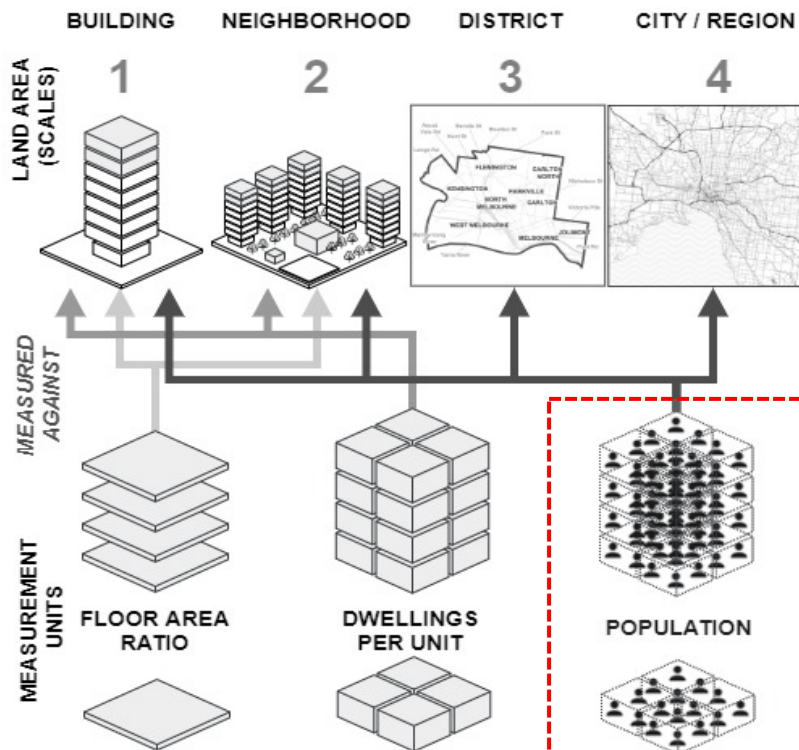


Measuring *i*ntensity and *f*requency of human activities

in Tmor-Da, an evolving settlement in Phnom Penh, Cambodia.

'I acknowledge the Traditional Owners of the land on which this event is taking place, the land of the [Wurundjeri], and pay respect to their Elders and families.' The University Melbourne, Australia.

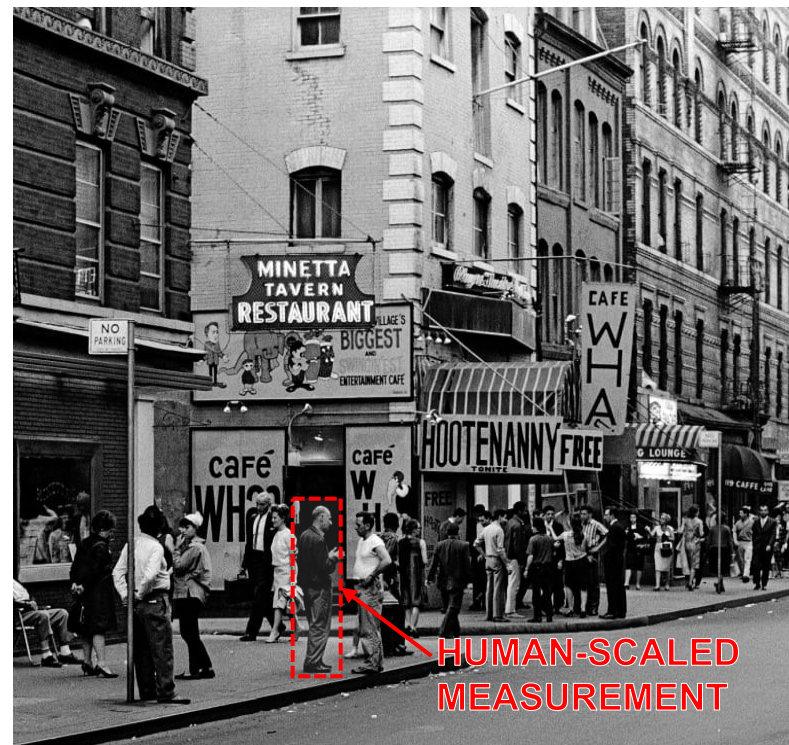
2.0 ISSUES



DENSITY



- MACRO-SCALE
- BROAD
- STATIC
- QUANTITATIVE INDICATORS
- PERCEPTUAL & CONCEPTUAL



INTENSITY



- MICRO-SCALE
- SPECIFIC = PRECISE
- QUALITATIVE: RELATE TO OTHER MODALITIES (POROSITY)
- QUANTITATIVE: MACRO-SCALED SURROUNDING

DENSITY

Cheng, V. (2009). [PDF] Understanding Density and High Density. Semantic Scholar. <https://doi.org/10.4324/9781849774444-11>

Density Atlas team (MIT). (2011). The Density Atlas. MIT Open Source. <http://densityatlas.org/measuring/>

Pont, M. B. (2010). Spacematrix : space, density, and urban form. NAI.

Rowland, I. D., Howe, T. N., & Dewar, M. J. (2014). Vitruvius: 'Ten books on architecture.' In Vitruvius: "Ten Books on Architecture." Cambridge University Press. <https://doi.org/10.1017/CBO9780511840951>

INTENSITY

QUALITATIVE

Dovey, K., & Pafka, E. (2016). Urban density matters – but what does it mean ? <https://theconversation.com/urban-density-matters-but-what-does-it-mean-58977>

Dovey, K., Pafka, E., & Ristic, M. (2017). Mapping Urbanities. In Mapping Urbanities. Routledge. <https://doi.org/10.4324/9781315309163>

Dovey, K., & Symons, F. (2012). Density without intensity and what to do about it: reassembling public/private interfaces in Melbourne's Southbank hinterland. Australian Planner, 51(1), 34–46. <https://doi.org/10.1080/07293682.2013.776975>

Dovey, K., & Wood, S. (2015). Public/private urban interfaces: type, adaptation, assemblage. Journal of Urbanism, 8(1), 1–16. <https://doi.org/10.1080/17549175.2014.891151>

Jacobs, J. (1961). The Death and Life of Great American Cities. The Failure of Town Planning. New York, 71, 474. <https://doi.org/10.2307/794509>

QUANTITATIVE

Porqueddu, E. (2015). Intensity without Density. Journal of Urban Design, 20(2), 169–192. <https://doi.org/10.1080/13574809.2015.1009008>

Rowe, P., & Kan, H. Y. (2014). Urban Intensities: Contemporary Housing Types and Territories - Harvard Graduate School of Design. Walter de Gruyter GmbH. <https://www.gsd.harvard.edu/publication/urban-intensities-contemporary-housing-types-and-territories/>

Sevtsuk, A., Ekmekci, O., Nixon, F., & Amindarbari, R. (2013). Capturing urban intensity. Open Systems - Proceedings of the 18th International Conference on Computer-Aided Architectural Design Research in Asia, CAADRIA 2013, 551–560. http://cumincad.scix.net/data/works/att/caadria2013_027.content.pdf

Stonor, T. (2019). Measuring Intensity - Describing and Analysing the “Urban Buzz.” Iconarp International J. of Architecture and Planning, 7(Special Issue “Urban Morphology”), 240–248. <https://doi.org/10.15320/iconarp.2019.87>



Purpose

improve upon the precision of density measurements for urban environments

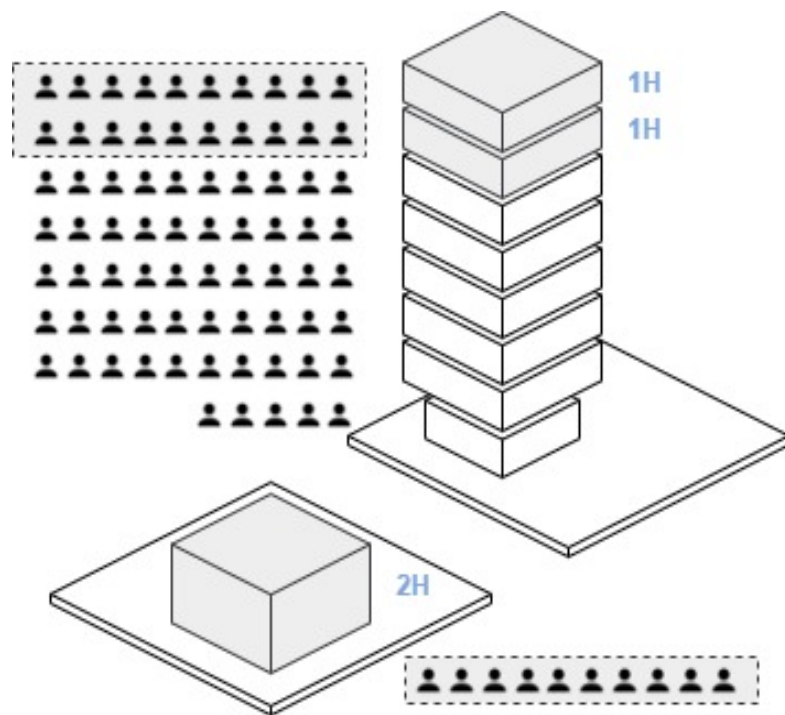
Aim

explore the plausibility of providing another form of quantitative indicator to the existing broad density calculations

Objective

introduce two novel equations to measure human activities

2.0 MEASUREMENT OF HUMAN ACTIVITIES



**Population
Density**

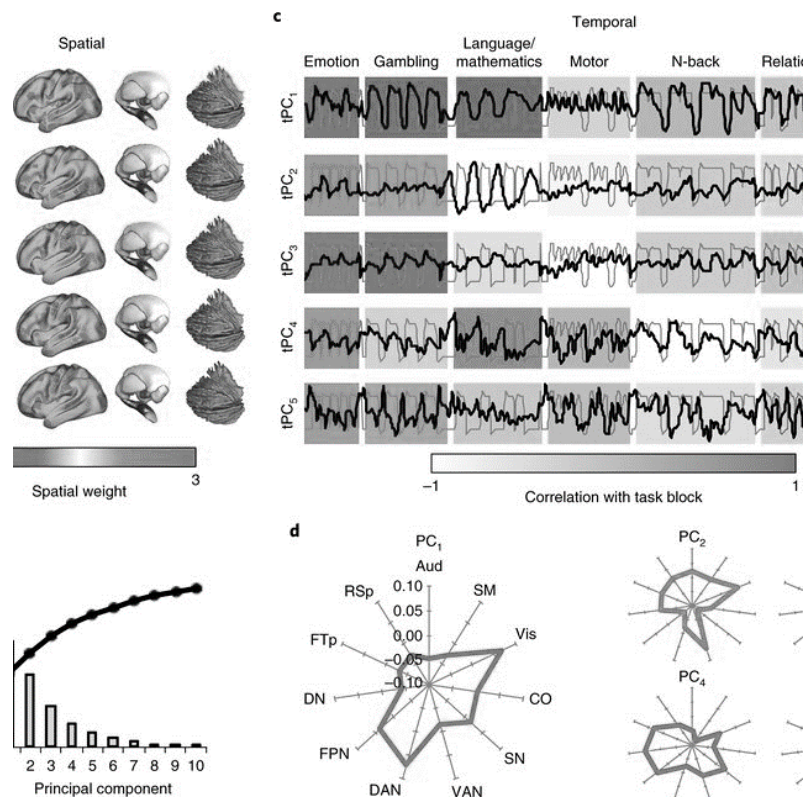


**Spatial-temporal
Mathematics**

References:

Density Atlas team (MIT). (2011). The Density Atlas. MIT Open Source.
<http://densityatlas.org/measuring/>

Rowland, I. D., Howe, T. N., & Dewar, M. J. (2014). Vitruvius: "Ten books on architecture." In Vitruvius: "Ten Books on Architecture." Cambridge University Press.
<https://doi.org/10.1017/CBO9780511840951>



References:

Weisstein; Eric (Wolfram research). (2020). Spatial-Temporal Point Process -- from Wolfram MathWorld. Wolfram Mathworld. <https://mathworld.wolfram.com/Spatial-TemporalPointProcess.html>

2.0 NOVEL EQUATIONS

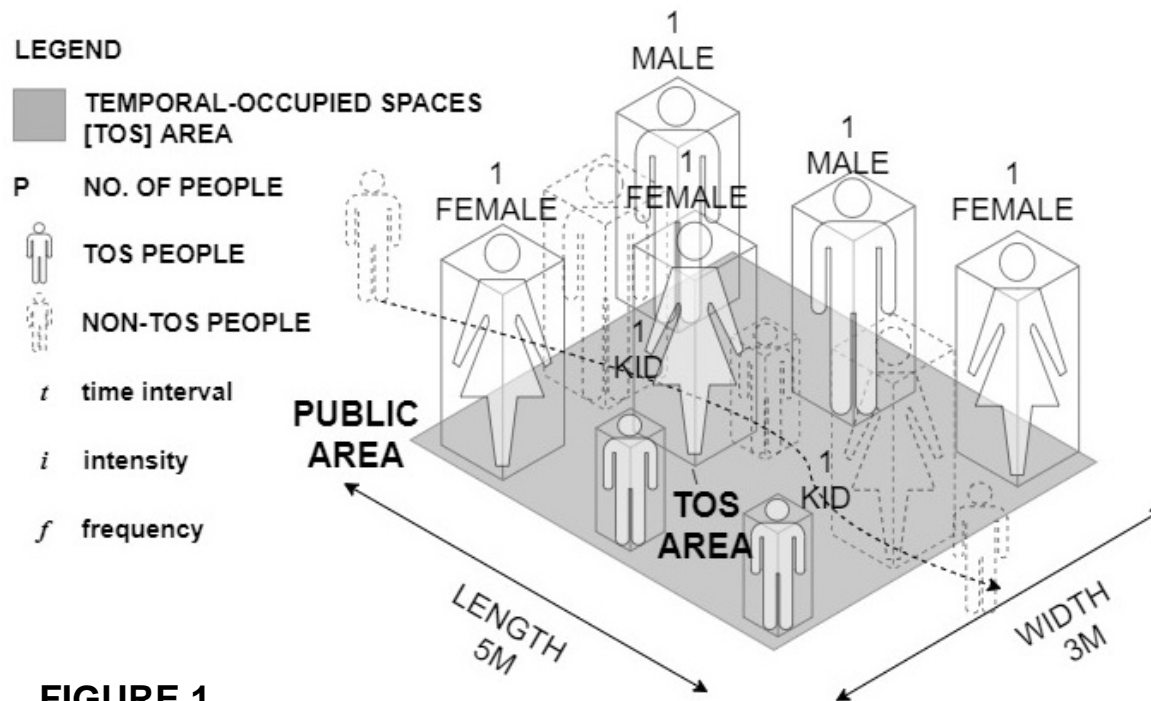


FIGURE 1

Measuring human activities

Equation 1:

Intensity of human activities (i)

$$i = \frac{P_{(TOS)}}{TOS} \text{ per } t$$

Equation 2:

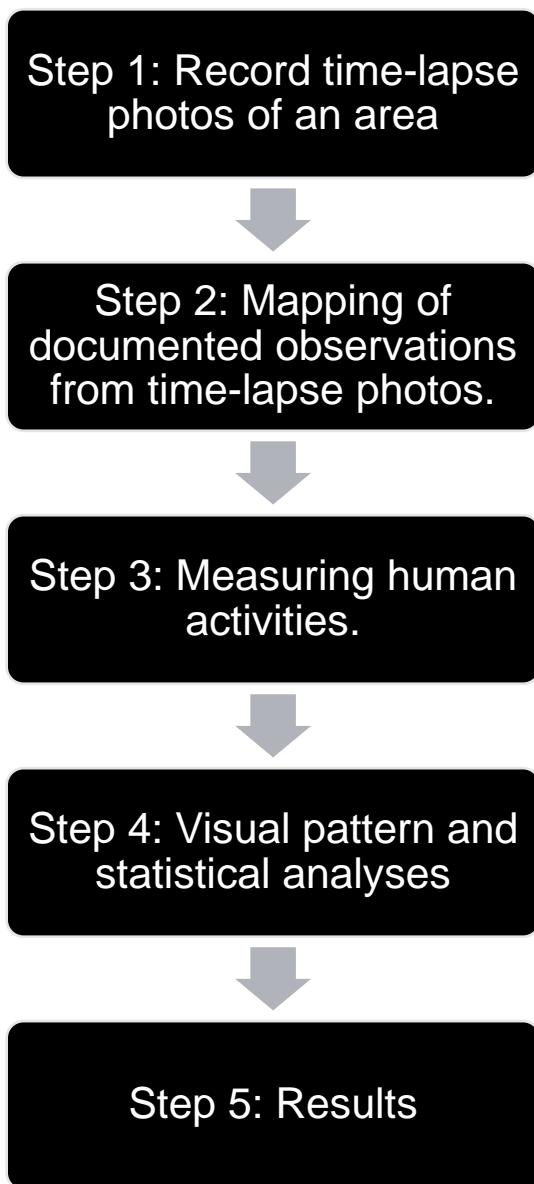
frequency of human activities (f)

$$f = \frac{P_{(NON - TOS)}}{TOS} \times t$$

3.0. EXPERIMENT: TESTING OF EQUATIONS ON A CASE STUDY



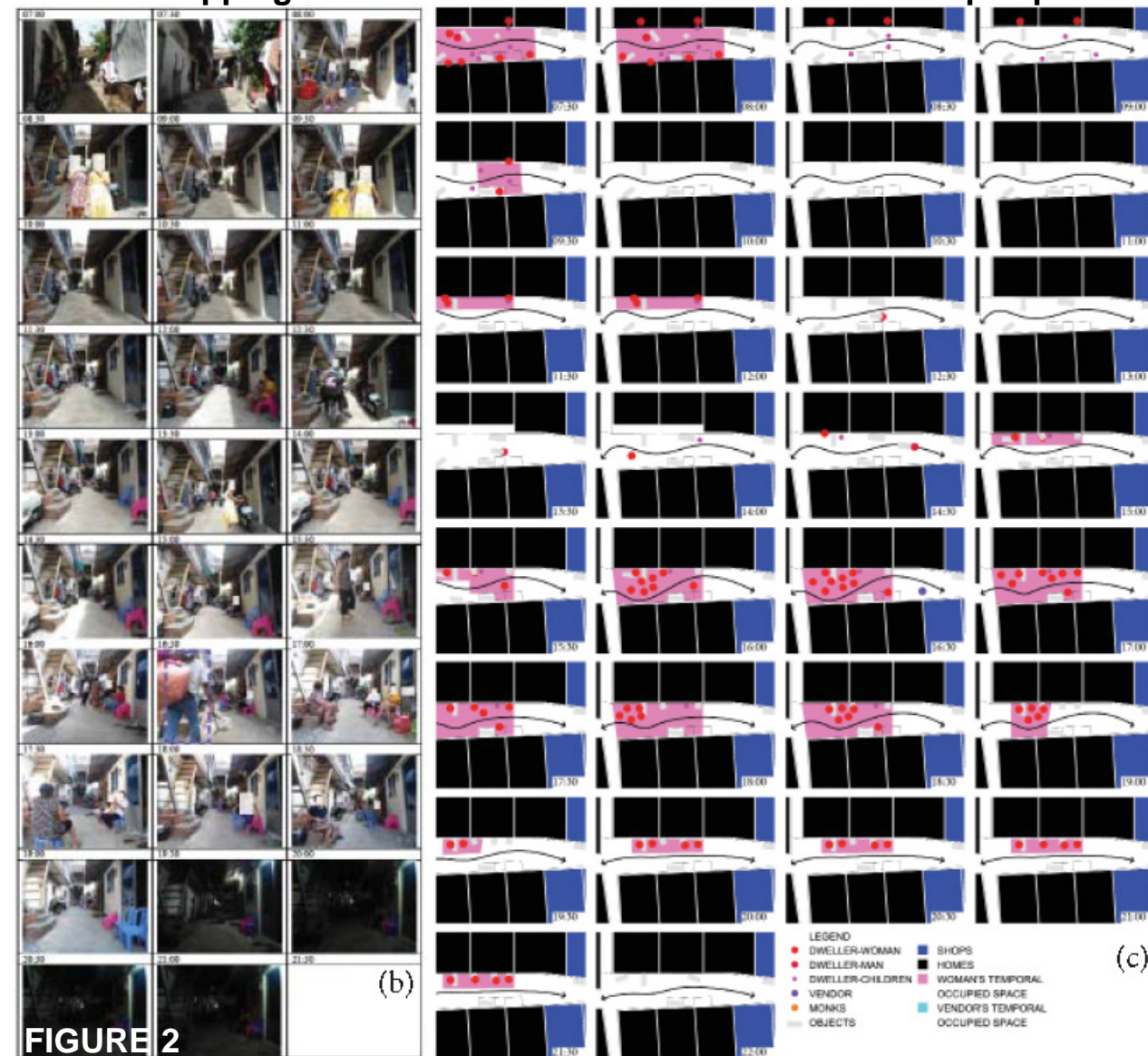
3.1 SELECT A CASE STUDY: TMOR-DA, PHNOM PENH, CAMBODIA



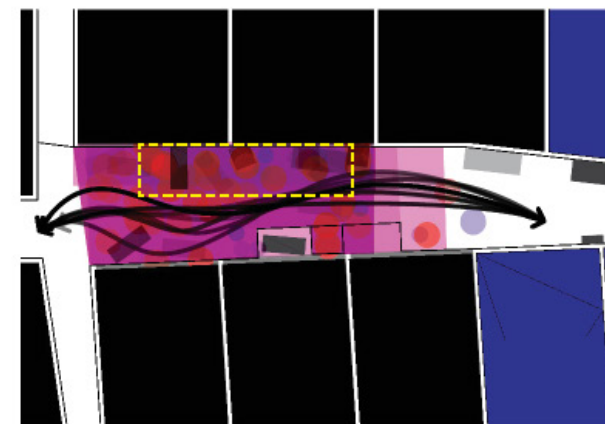
3.3 ZONE 1 : A TYPICAL DWELLING AREA

STEP 1: Recorded time-lapse photos of an area in figure 2(b).

STEP 2: Mapping of documented observations from time-lapse photos in figure 2(c).



(a)



(d)

STEP 4: Spatial intensity analysis in figure 1 (d).

3.3 ZONE 1

STEP 3: Measuring human activities in Table 1

$$i = \frac{P_{(TOS)}}{TOS} \text{ per } t$$

$$f = \frac{P_{(NON - TOS)}}{TOS} \times t$$

t

TOS

P

intensity

frequency

ZONE 1	TEMPORAL OCCUPIED SPACE (TOS) (SQM)			AREA (SQM)	NO. OF PEOPLE						UNIT			HUMAN	PER-MINUTE		HUMAN
	{PINK}	{CYAN}	AREA (SQM)									{PINK}	{CYAN}	INTENSITY	{PINK}	{CYAN}	FREQUENCY
TIME	DOMESTIC	COMMERCIAL	TOTAL TOS	SHOP (BLUE)	D-FEMALE	D-MALE	D-KID	VENDOR	non-occupy	TOTAL	OBJECTS	DOMESTIC	COMMERCIAL	TOTAL	DOMESTIC	COMMERCIAL	TOTAL
07:30	24.99	0	24.99	0	6	1	4	0	0	11	8	0.44		0.44	0.00		0.01
08:00	25.07	0	25.07	0	6	1	4	0	0	11	8	0.44		0.44	0.00		0.01
08:30	0	0	0	0	2	0	3	0	3	5	8	0.00		0.00			0.00
09:00	0	0	0	0	2	0	3	0	3	5	7	0.00		0.00			0.00
09:30	8.25	0	8.25	0	2	0	3	0	2	5	7	0.61		0.61	0.01		0.02
10:00	0	0	0	0	0	0	0	0	0	0	7	0.00		0.00			0.00
10:30	0	0	0	0	1	1	0	0	0	2	6	0.00		0.00			0.00
11:00	0	0	0	0	1	1	0	0	0	2	6	0.00		0.00			0.00
11:30	0	0	0	0	1	1	0	0	0	2	6	0.00		0.00			0.00
12:00	7.58	0	7.58	0	3	0	1	0	0	4	6	0.53		0.53	0.00		0.02
12:30	0	0	0	0	0	1	0	0	1	1	8	0.00		0.00			0.00
13:00	0	0	0	0	0	0	0	0	0	0	7	0.00		0.00			0.00
13:30	0	0	0	0	0	1	0	0	1	1	8	0.00		0.00			0.00
14:00	0	0	0	0	1	0	1	0	2	2	6	0.00		0.00			0.00
14:30	0	0	0	0	1	0	1	0	3	2	7	0.00		0.00			0.00
15:00	7.34	0	7.34	0	2	0	1	0	0	3	9	0.41		0.41	0.00		0.01
15:30	12.26	0	12.26	0	3	0	1	0	0	4	9	0.33		0.33	0.00		0.01
16:00	19.74	0	19.74	0	8	0	1	0	0	9	8	0.46		0.46	0.00		0.02
16:30	19.74	0	19.74	0	9	0	1	1	1	11	6	0.56		0.56	0.00		0.02
17:00	19.74	0	19.74	0	8	0	1	0	0	9	6	0.46		0.46	0.00		0.02
17:30	19.74	0	19.74	0	5	0	1	0	0	6	7	0.30		0.30	0.00		0.01
18:00	19.74	0	19.74	0	4	0	1	0	0	5	7	0.25		0.25	0.00		0.01
18:30	19.74	0	19.74	0	6	0	1	0	0	7	7	0.35		0.35	0.00		0.01
19:00	8.92	0	8.92	0	5	0	0	0	0	5	8	0.56		0.56	0.00		0.02
19:30	4.08	0	4.08	0	2	0	0	0	0	2	8	0.49		0.49	0.00		0.02
20:00	7.09	0	7.09	0	4	0	0	0	0	4	8	0.56		0.56	0.00		0.02
20:30	7.09	0	7.09	0	4	0	0	0	0	4	8	0.56		0.56	0.00		0.02
21:00	7.09	0	7.09	0	4	0	0	0	0	4	8	0.56		0.56	0.00		0.02
21:30	7.09	0	7.09	0	4	0	0	0	0	4	8	0.56		0.56	0.00		0.02
22:00	0	0	0	0	0	0	0	0	0	0	0	0.00		0.00			0.00
TOTAL	245.29	0.00	245.29	0.00	94.00	7.00	28.00	1.00		130.00	212.00	0.53		0.53	0.02		0.02
N	30																
MEAN	8.18		8.18		3.13	0.23	0.93	0.03		4.33	7.07	0.53		0.53	0.02		0.02
MEDIAN	7.09		7.09		2.50	0.00	1.00	0.00		4.00	7.00	0.56		0.56	0.02		0.02
Mode	0.00		0.00		4.00	0.00	0.00	0.00		4.00	16.00	0.00		0.00	0.00		0.00
Std Dev	8.73		8.73		2.60	0.43	1.23	0.18		3.23	1.62	0.25		0.25	0.00		0.01
Variance	76.29		76.29		6.74	0.19	1.51	0.03		10.44	2.62	0.06		0.06	0.00		0.00

Temporal-occupied spaces (area)

Types of people

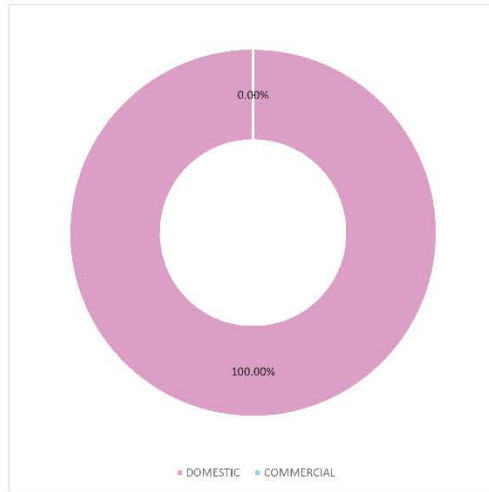
Measurement of Human activities

TABLE 1

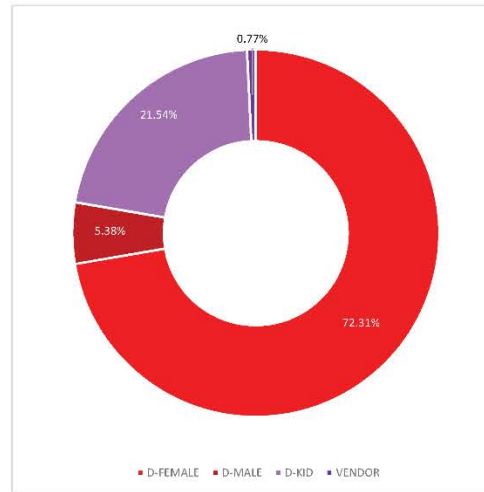
3.3 ZONE 1

STEP 4: Statistical analyses in Figure 3

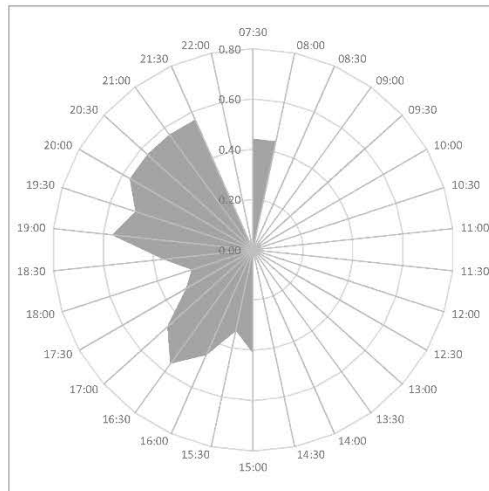
STEP 5: Results



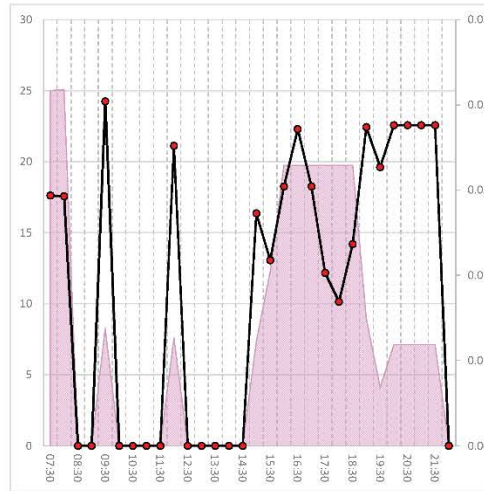
ZONE 1 (a) Donut chart of total domestic and commercial TOS in a day



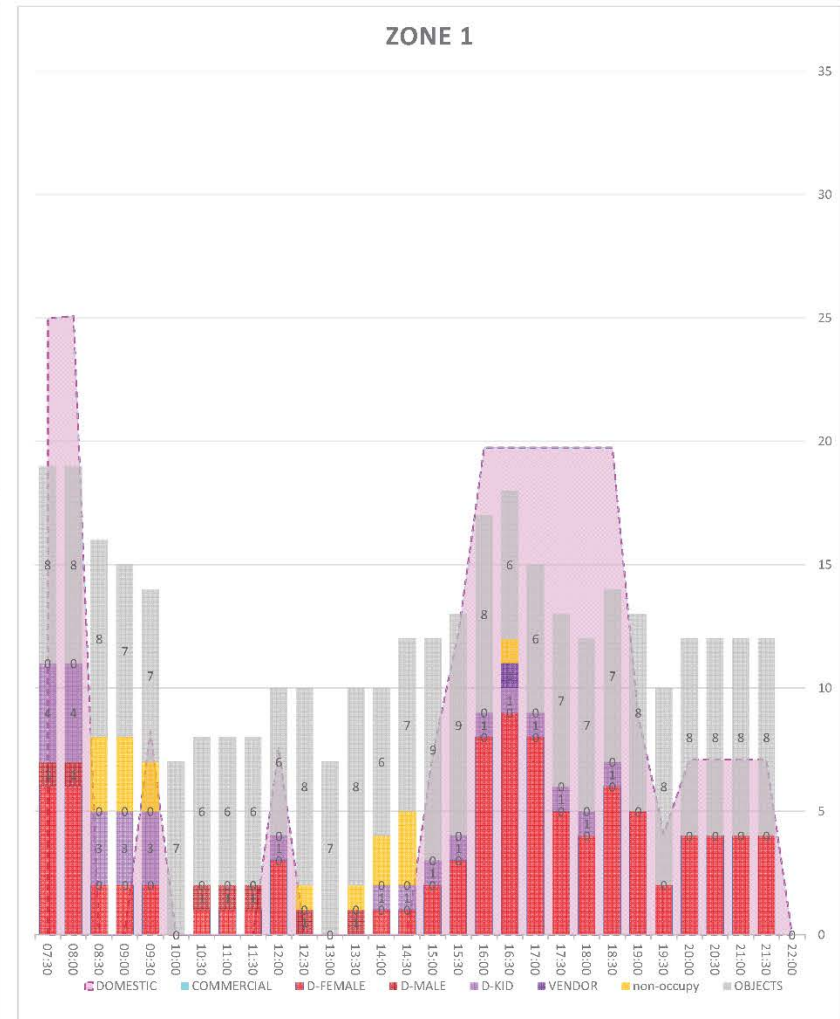
ZONE 1 (b) Donut chart of total people on TOS in a day



ZONE 1 (c) Donut chart of human intensity on TOS in a day (07:30 to 22:00)



ZONE 1 (d) Time-series plot of human frequency on TOS in a day



ZONE 1: (e) Combination of bar and hatched line chart with time interval range along horizontal row. The bar consists of stacked vertical columns of different types of people and objects, with a hatched line chart of the TOS area at the back.

FIGURE 3

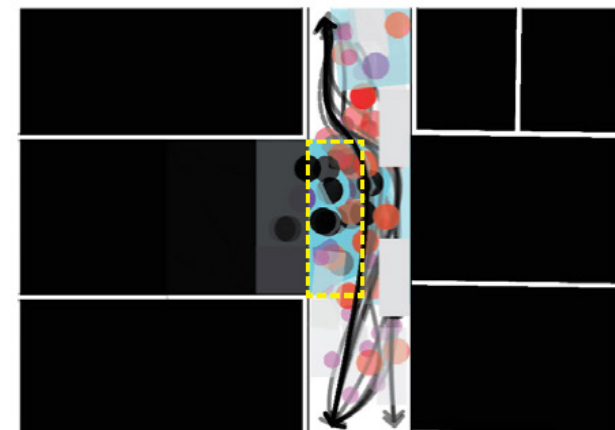
3.4 ZONE 5 : THE BOILED EGG-EMBRYOS SELLER

STEP 1: Recorded time-lapse photos of an area in figure 4(b).

STEP 2: Mapping of documented observations from time-lapse photos in figure 4(c).



(a)



STEP 4: Spatial intensity analysis in figure 4 (d).

(d)

FIGURE 4

3.4 ZONE 5

STEP 3: Measuring human activities in Table 2

$$i = \frac{P_{(TOS)}}{TOS} \text{ per } t$$

$$f = \frac{P_{(NON - TOS)}}{TOS} \times t$$

t

TOS

P

intensity

frequency

ZONE 5	TEMPORAL OCCUPIED SPACE [TOS] (SQM)				AREA (SQM)	NO. OF PEOPLE						UNIT			HUMAN	PER-MINUTE		HUMAN
	(PINK)	(CYAN)	AREA(SQM)							(PINK)	(CYAN)		INTENSITY	(PINK)	(CYAN)	FREQUENCY		
	TIME	DOMESTIC	COMMERCIAL	TOTAL		SHOP (BLUE)	D-FEMALE	D-MALE	D-KID	VENDOR	non-occupy	TOTAL	OBJECTS	DOMESTIC	COMMERCIAL	TOTAL	DOMESTIC	COMMERCIAL
07:30	0	9.16	9.16	8.45	0	0	0	1	0	1	4		0.11	0.11			0.00	0.00
08:00	0	9.54	9.54	8.45	0	1	0	1	0	2	4		0.21	0.21			0.00	0.01
08:30	0	11.61	11.61	8.45	1	3	0	1	0	5	5		0.43	0.43			0.00	0.01
09:00	0	15.46	15.46	8.45	2	3	2	1	3	8	7		0.52	0.52			0.01	0.02
09:30	0	10.54	10.54	8.45	0	1	0	1	4	2	5		0.19	0.19			0.01	0.01
10:00	0	10.59	10.59	8.45	0	0	0	1	0	1	7		0.09	0.09			0.00	0.00
10:30	0	10.59	10.59	8.45	0	0	0	1	0	1	8		0.09	0.09			0.00	0.00
11:00	0	10.59	10.59	8.45	3	0	0	1	0	4	6		0.38	0.38			0.00	0.01
11:30	0	10.59	10.59	8.45	3	0	0	1	0	4	6		0.38	0.38			0.00	0.01
12:00	0	9.12	9.12	8.45	0	1	1	0	0	2	3		0.22	0.22			0.00	0.01
12:30	0	5.2	5.2	9.95	0	0	0	1	0	1	3		0.19	0.19			0.00	0.01
13:00	0	5.2	5.2	9.95	1	0	0	1	0	2	3		0.38	0.38			0.00	0.01
13:30	0	5.2	5.2	9.95	2	0	2	1	0	5	4		0.96	0.96			0.00	0.03
14:00	0	5.2	5.2	9.95	1	0	2	1	0	4	6		0.77	0.77			0.00	0.03
14:30	0	5.2	5.2	9.95	1	0	0	1	0	2	6		0.38	0.38			0.00	0.01
15:00	0	5.2	5.2	9.95	1	1	0	1	0	3	6		0.58	0.58			0.00	0.02
15:30	0	5.2	5.2	9.95	2	1	0	1	0	4	6		0.77	0.77			0.00	0.03
16:00	0	5.2	5.2	9.95	1	0	2	1	0	4	6		0.77	0.77			0.00	0.03
16:30	0	5.2	5.2	9.95	2	0	0	1	0	3	6		0.58	0.58			0.00	0.02
17:00	0	5.2	5.2	9.95	0	0	0	1	0	1	6		0.19	0.19			0.00	0.01
17:30	0	5.2	5.2	9.95	0	0	2	1	0	3	6		0.58	0.58			0.00	0.02
18:00	0	5.2	5.2	1.52	1	0	0	1	0	2	5		0.38	0.38			0.00	0.01
18:30	0	5.73	5.73	1.52	2	1	2	2	0	7	6		1.22	1.22			0.00	0.04
19:00	0	4.74	4.74	1.52	0	0	0	1	0	1	5		0.21	0.21			0.00	0.01
19:30	0	4.66	4.66	1.52	1	0	0	1	0	2	5		0.43	0.43			0.00	0.01
20:00	0	0	0	0	0	0	0	0	0	0	4			0.00			0.00	0.00
20:30	0	0	0	0	0	0	0	0	0	0	4			0.00			0.00	0.00
21:00	0	0	0	0	0	0	0	0	0	0	4			0.00			0.00	0.00
21:30	0	0	0	0	0	0	0	0	0	0	4			0.00			0.00	0.00
22:00	0	0	0	0	0	0	0	0	0	0	4			0.00			0.00	0.00
Average	0.00	185.32	185.32	200.03	24.00	12.00	13.00	25.00		74.00	154.00		0.40	0.40			0.01	0.01
N	30																	
MEAN		6.18	6.18	6.67	0.80	0.40	0.43	0.83		2.47	5.13		0.40	0.40			0.01	0.01
MEDIAN		5.20	5.20	8.45	0.50	0.00	0.00	1.00		2.00	5.00		0.38	0.38			0.01	0.01
Mode		10.40	10.40	19.90	0.00	0.00	0.00	2.00		4.00	12.00		0.77	0.00			0.00	0.00
Std Dev		3.93	3.93	4.06	0.96	0.81	0.82	0.46		2.05	1.28		0.29	0.31			0.00	0.01
Variance		15.46	15.46	16.50	0.92	0.66	0.67	0.21		4.19	1.64		0.08	0.10			0.00	0.00

Temporal-occupied spaces (area)

Types of people

Measurement of Human activities

TABLE 2

Measuring intensity and frequency of human activities.

Author / Presenter : YeeKee Ku

3.4 ZONE 5

STEP 4: Statistical analyses in Figure 5

STEP 5: Results

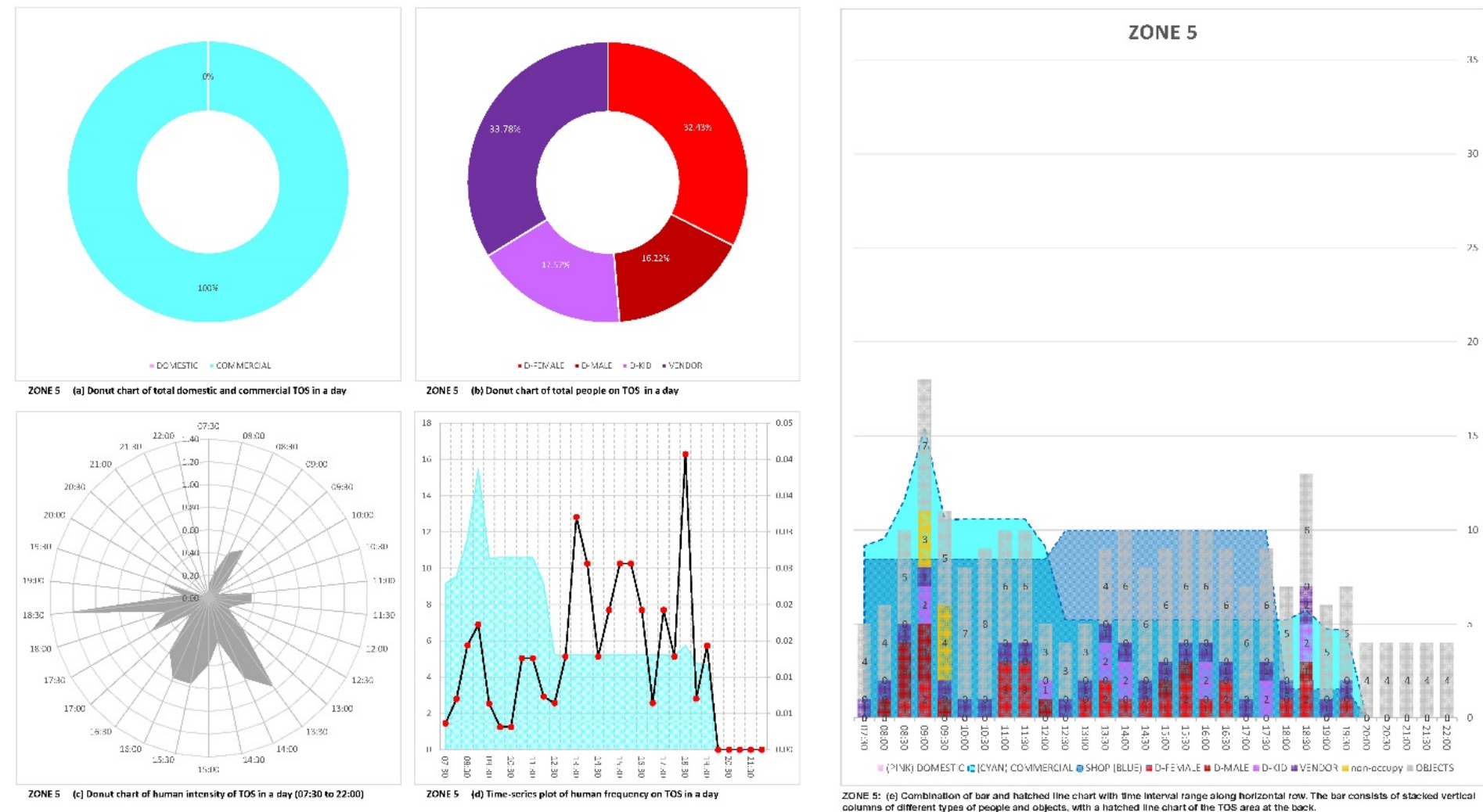


FIGURE 5

CUSTOMISABLE VARIABLES

TOS

TEMPORAL-OCCUPIED SPACES

VARIABLE

CUSTOMIZATION TO:

1. ACTIVITIES & SUBCATEGORIES
2. PUBLIC OR PRIVATE STATE
3. OUTDOOR OR INDOOR
4. ETC

P

NO. OF PEOPLE

VARIABLE

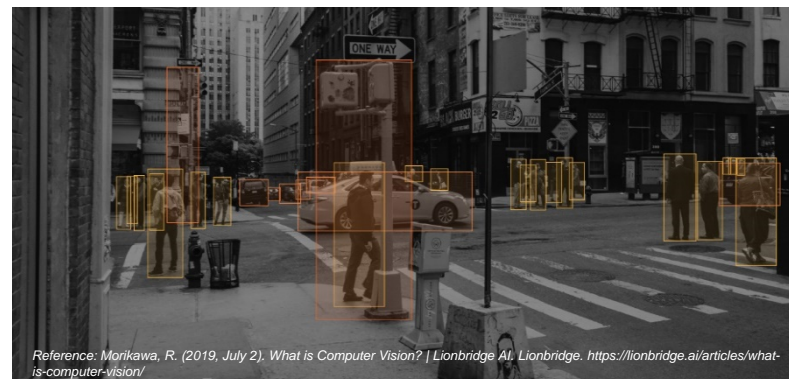
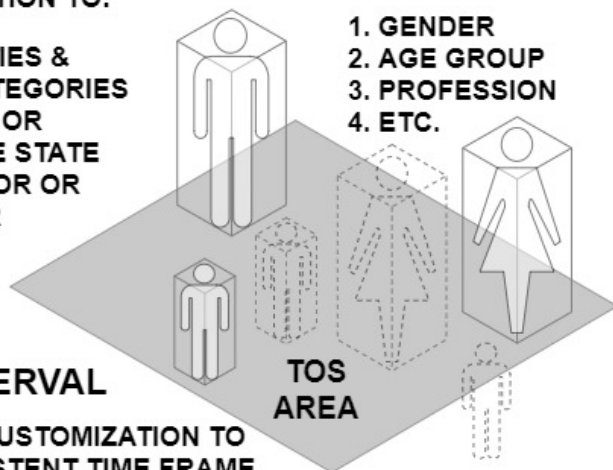
CUSTOMIZATION TO:

1. GENDER
2. AGE GROUP
3. PROFESSION
4. ETC.

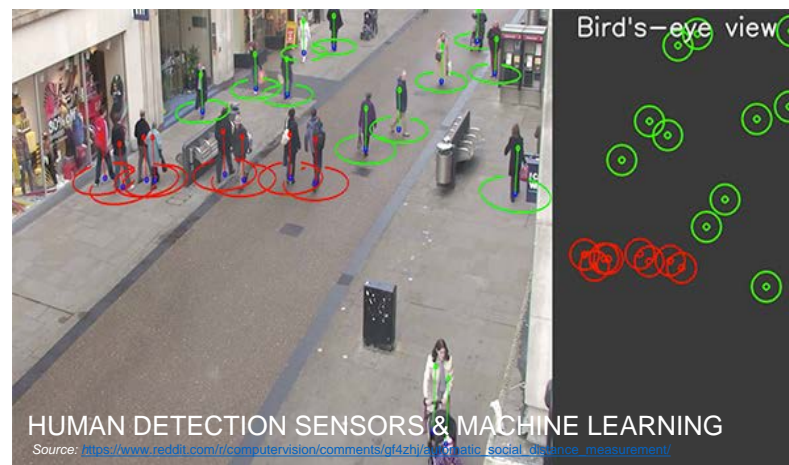
t

TIME INTERVAL

VARIABLE CUSTOMIZATION TO ANY CONSISTENT TIME FRAME



QUANTITATIVE FACTOR OF HUMAN ACTIVITIES



QUANTITATIVE INDICATOR OF REAL-TIME DENSITY

TIME	POPULATION DENSITY ESTIMATION	HUMAN INTENSITY MEAN (ZONE 1 + 5)	HUMAN FREQUENCY	HUMAN INTENSITY ZONE 1	HUMAN FREQUENCY ZONE 1	HUMAN INTENSITY ZONE 5	HUMAN FREQUENCY ZONE 5
07:30	2736	752	20	1204	40	299	0
08:00	2736	887	20	1200	40	574	0
08:30	2736	589	0	0	0	1178	0
09:00	2736	708	9	0	0	1416	18
09:30	2736	1089	45	1658	55	519	35
10:00	2736	129	0	0	0	258	0
10:30	2736	129	0	0	0	258	0
11:00	2736	517	0	0	0	1033	0
11:30	2736	517	0	0	0	1033	0
12:00	2736	1022	24	1444	48	600	0
12:30	2736	263	0	0	0	526	0
13:00	2736	526	0	0	0	1052	0
13:30	2736	1315	0	0	0	2631	0
14:00	2736	1052	0	0	0	2105	0
14:30	2736	526	0	0	0	1052	0
15:00	2736	1348	19	1118	37	1578	0
15:30	2736	1499	15	893	30	2105	0
16:00	2736	1676	21	1247	42	2105	0
16:30	2736	1552	25	1525	51	1578	0
17:00	2736	887	21	1247	42	526	0
17:30	2736	1205	14	832	28	1578	0
18:00	2736	873	12	693	23	1052	0
18:30	2736	2156	16	970	32	3342	0
19:00	2736	1055	26	1534	51	577	0
19:30	2736	1258	22	1341	45	1174	0
20:00	2736	772	26	1544	51	0	0
20:30	2736	772	26	1544	51	0	0
21:00	2736	772	26	1544	51	0	0
21:30	2736	772	26	1544	51	0	0
22:00	2736	725	24	1450	48	0	0
Average	2736	911	15	818	27	1005	2

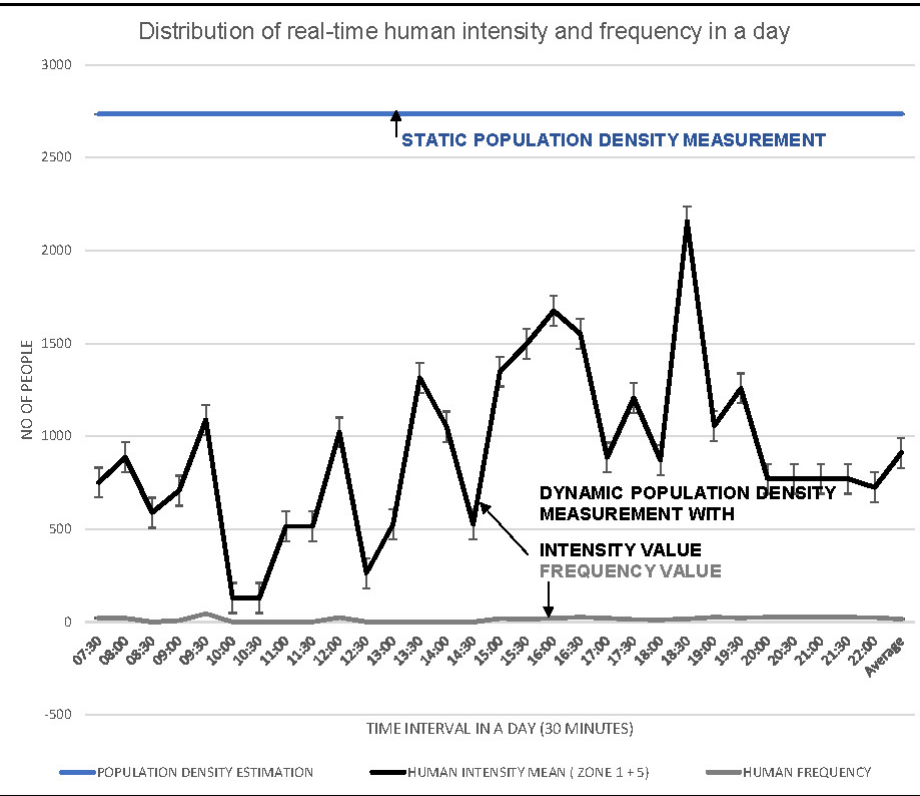
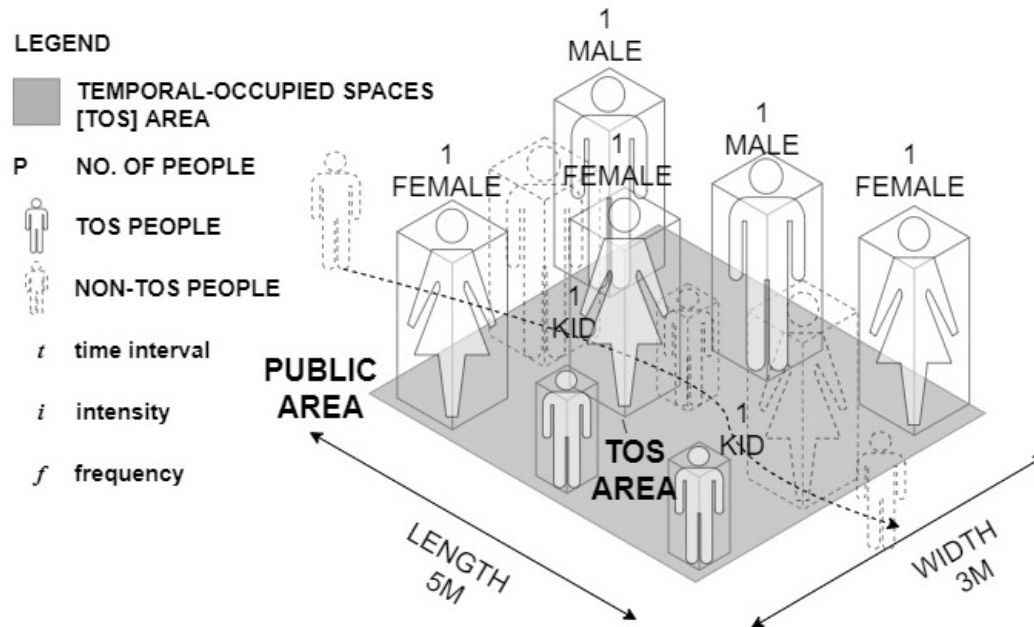


TABLE 3

FIGURE 6

'Kia ora' + Q&A ?



Measuring human activities

Equation 1:

Intensity of human activities (i)

$$i = \frac{P_{(TOS)}}{TOS} \text{ per } t$$

Equation 2:

frequency of human activities (f)

$$f = \frac{P_{(NON - TOS)}}{TOS} \times t$$