Method for measurement of the Dynamic Clothing Factor (D-CLO) for better OB modelling

Jakub Dziedzic

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DTU

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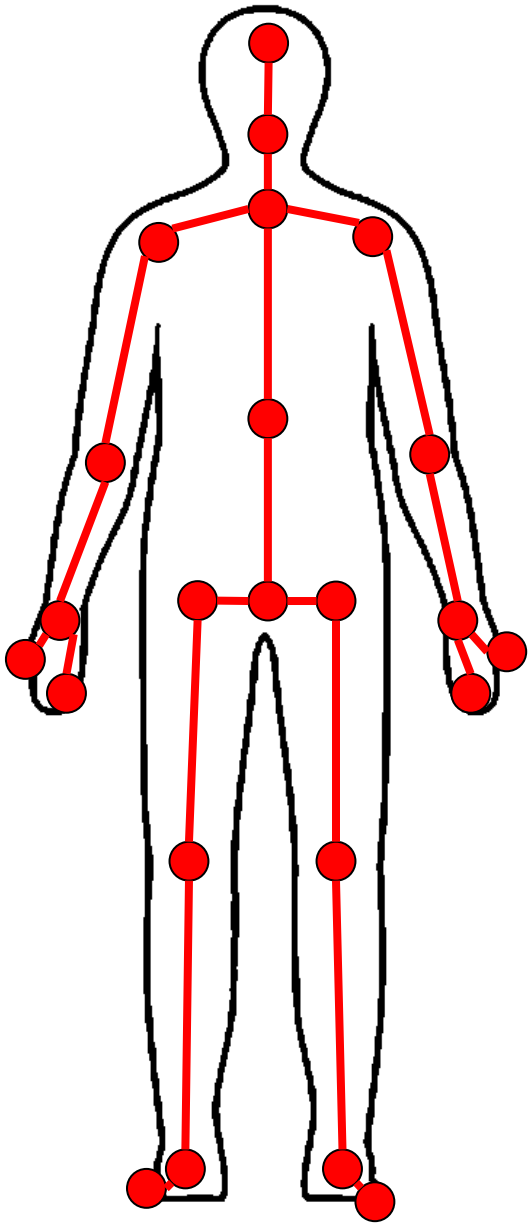
Norwegian University of Science and Technology

Using Xbox Kinect in OB Research

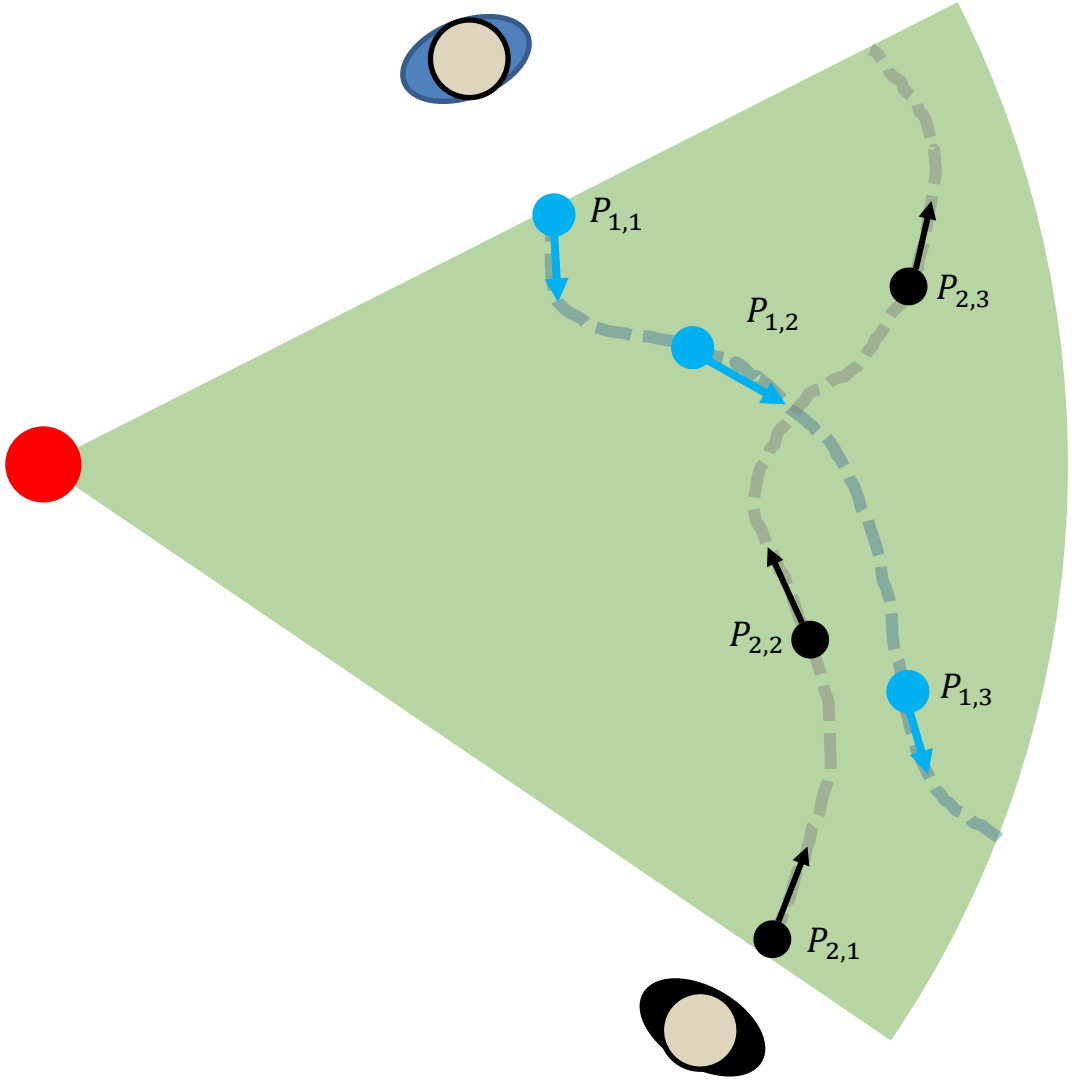
- **Microsoft device used for entertainment**
- **A depth registration camera able to capture human activity**

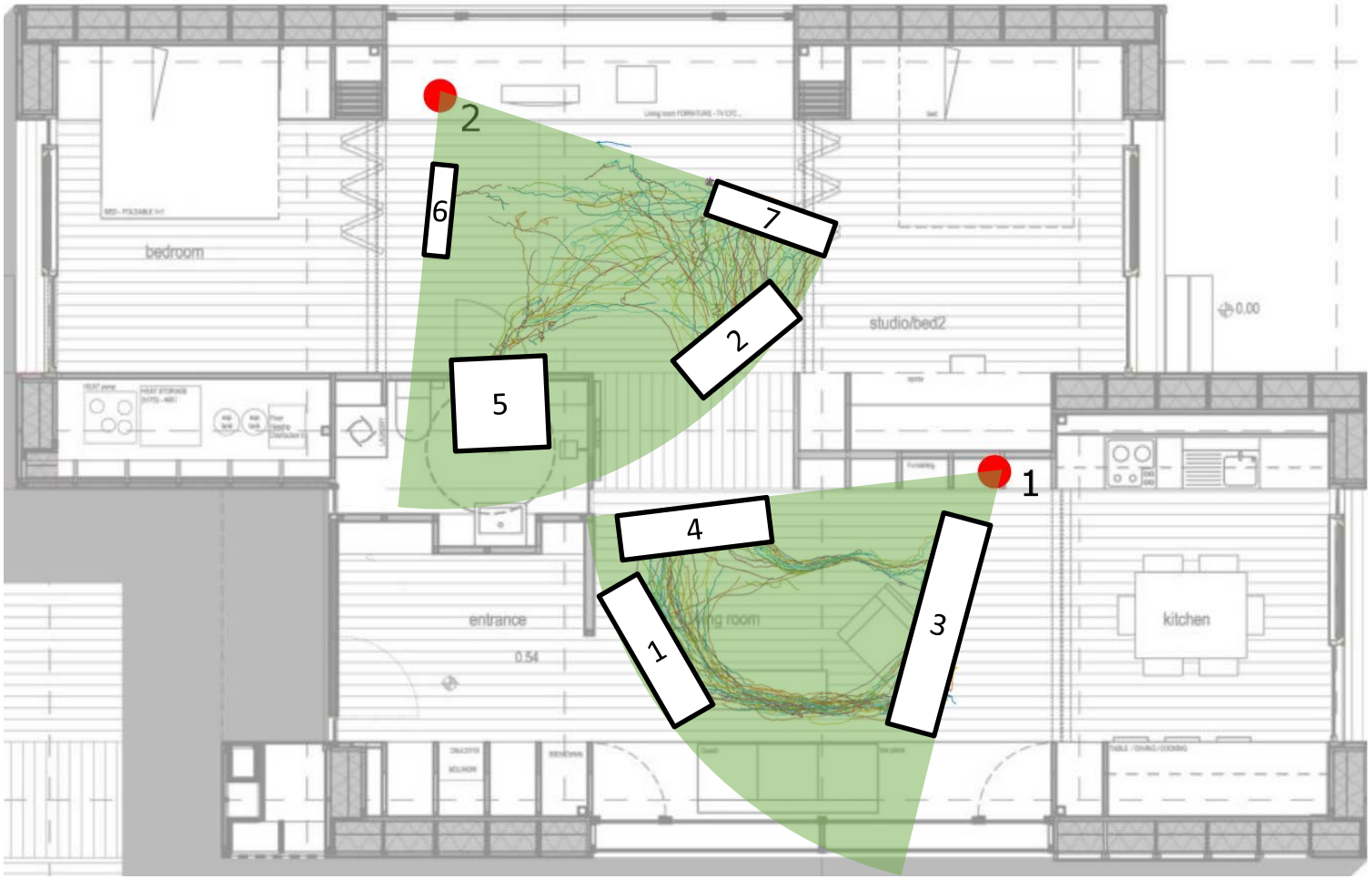
- **We started with monitoring and registration of occupant movement in the ZEB Living LAB**
- **Now expanding to observation and registration of dynamics of Met and Clo factors**

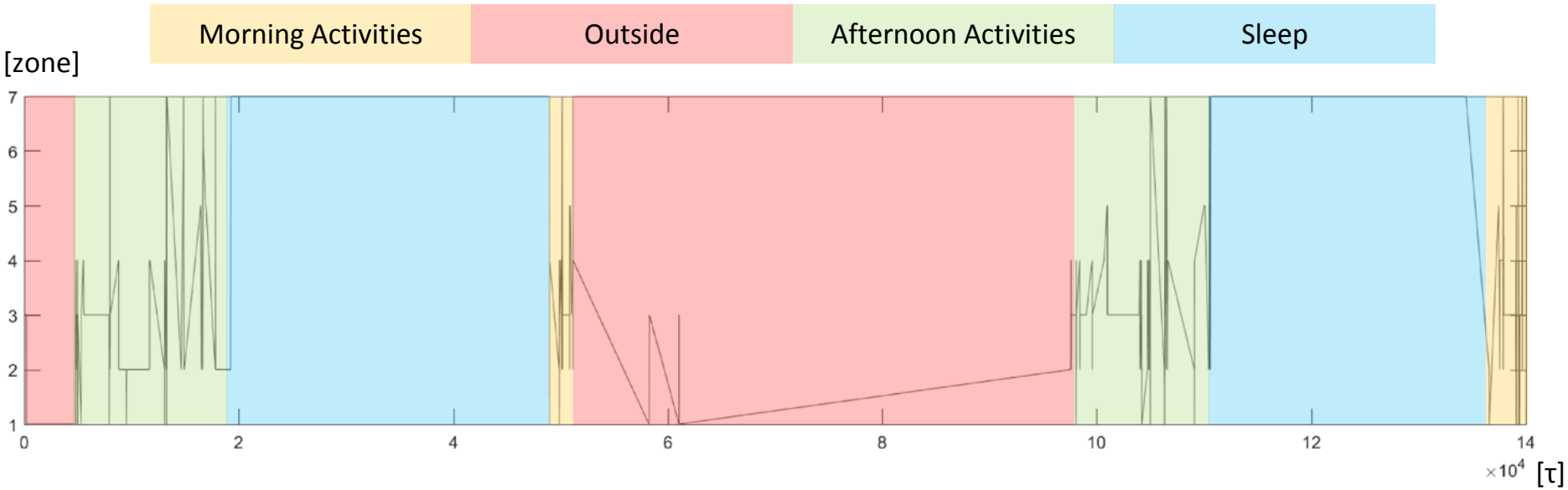
- Data for one person:
  25 point in 3D(X,Y,Z) + Clock data (Y/M/D/h/min/s/Frame)
- Data information: Distance from device [m]
- Registration speed: up to 30 [Hz]
- Registration limitations: up to 6 people in one time
- Example:[6*3*25 + 7=457]

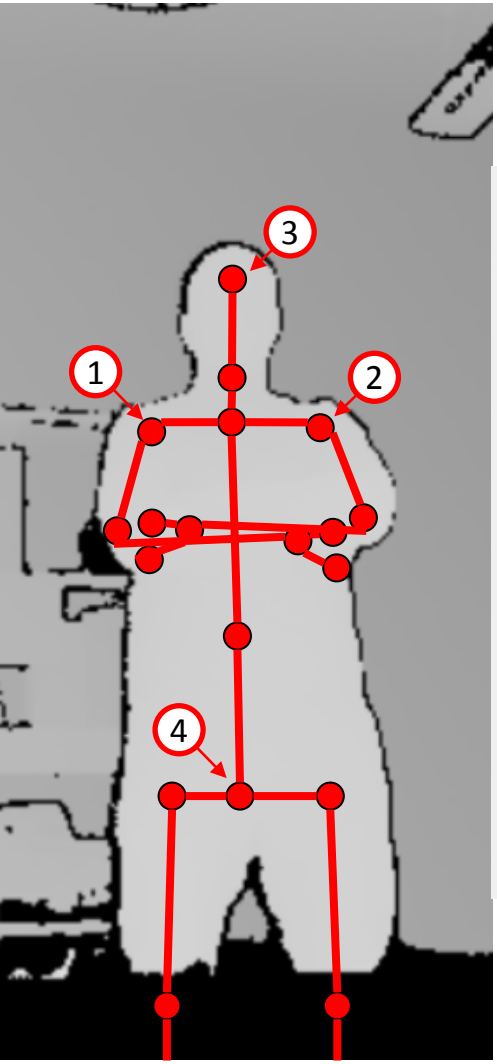


	X	Y	Z
SpineBase = 1;	0.1066	-0.2272	2.3211
SpineMid = 2;	0.0990	0.0792	2.3576
Neck = 3;	0.0903	0.3762	2.3800
Head = 4;	0.0832	0.5278	2.3588
ShoulderLeft = 5;	-0.0939	0.2785	2.3739
ElbowLeft = 6;	-0.2182	0.0450	2.3635
WristLeft = 7;	-0.3324	-0.1487	2.3171
HandLeft = 8;	-0.3879	-0.1982	2.2953
ShoulderRight = 9;	0.2749	0.2756	2.3563
ElbowRight = 10;	0.4278	0.0628	2.3095
WristRight = 11;	0.5774	-0.0988	2.2356
HandRight = 12;	0.6207	-0.1409	2.2146
HipLeft = 13;	0.0210	-0.2271	2.2906
KneeLeft = 14;	-0.0017	-0.5919	2.2254
AnkleLeft = 15;	-0.0485	-0.8850	2.1211
FootLeft = 16;	-0.0264	-0.7374	2.1179
HipRight = 17;	0.1888	-0.2196	2.2758
KneeRight = 18;	0.2266	-0.5835	2.2297
AnkleRight = 19;	0.2552	-0.8882	2.1656
FootRight = 20;	0.2160	-0.7434	2.1606
SpineShoulder = 21;	0.0926	0.3032	2.3768
HandTipLeft = 22;	-0.4402	-0.2368	2.2771
ThumbLeft = 23;	-0.3892	-0.1488	2.2181
HandTipRight = 24;	0.6720	-0.1895	2.1962
ThumbRight = 25;	0.6357	-0.0864	2.1534

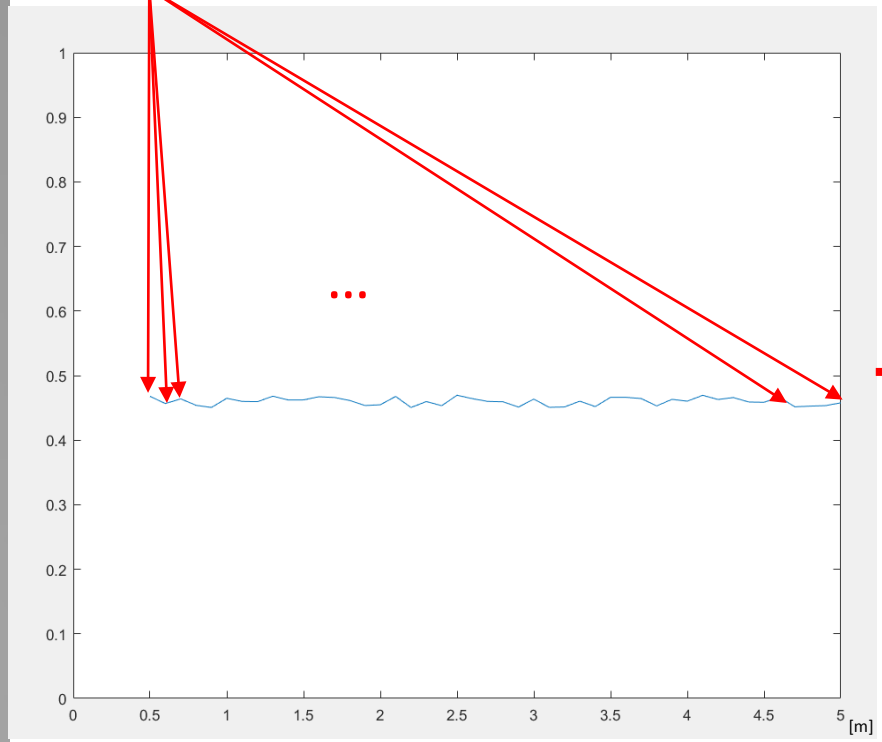

$P_{1,1}$
$P_{1,2}$
$P_{2,3}$
$P_{2,2}$
$P_{1,3}$
$P_{2,1}$

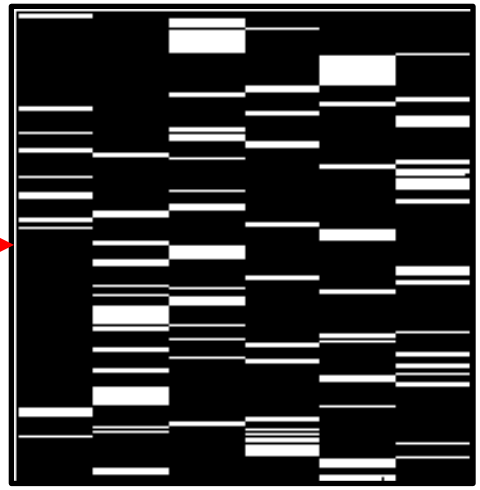

2
6
7
2
5
1
4
1
3
bedroom
studio/bed2
entrance
kitchen
0.00
0.54


Morning Activities
Outside
Afternoon Activities
Sleep
[zone]
7
6
5
4
3
2
1
0
2
4
6
8
10
12
14
×10^4
[τ]

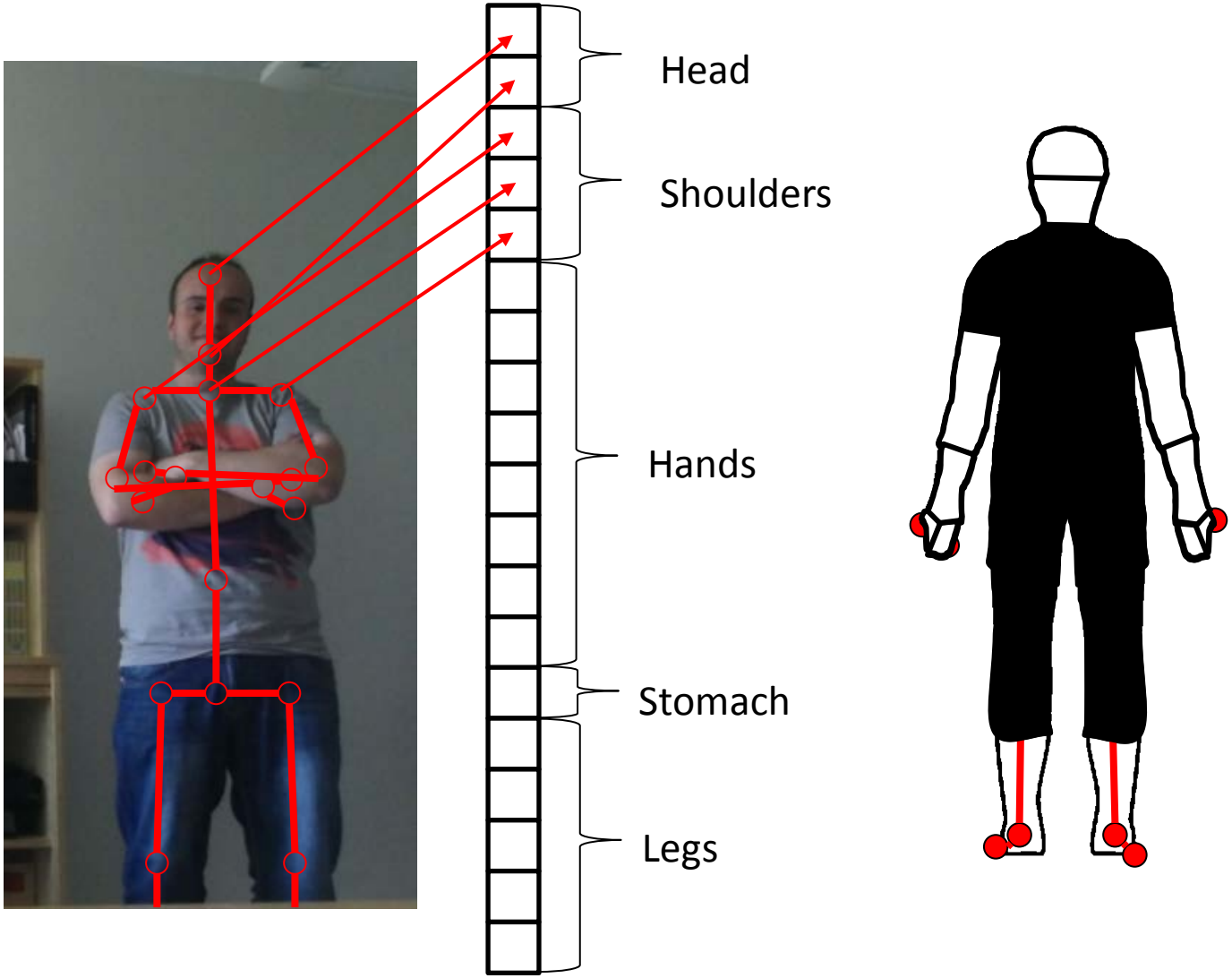


$$R_{1,i} = \frac{\sqrt{(x_2 - x_1)^2 + (y_2 - y_1)^2 + (z_2 - z_1)^2}}{\sqrt{(x_4 - x_3)^2 + (y_4 - y_3)^2 + (z_4 - z_3)^2}}$$

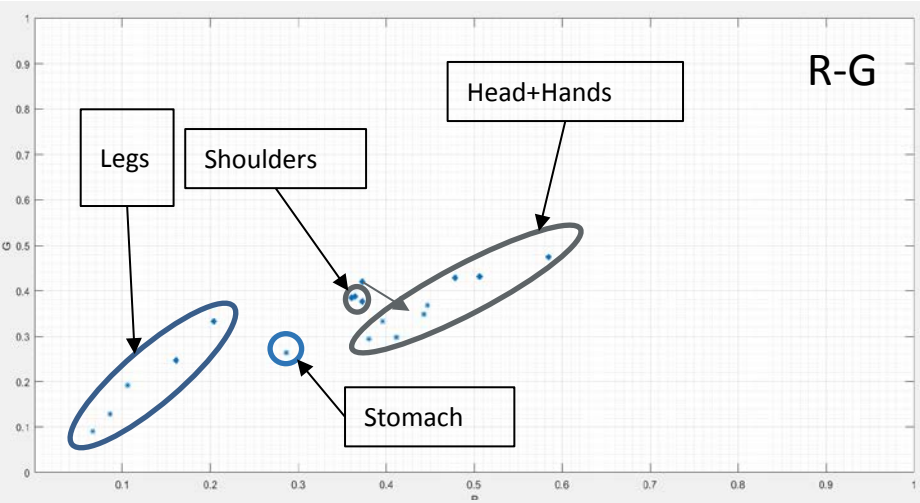


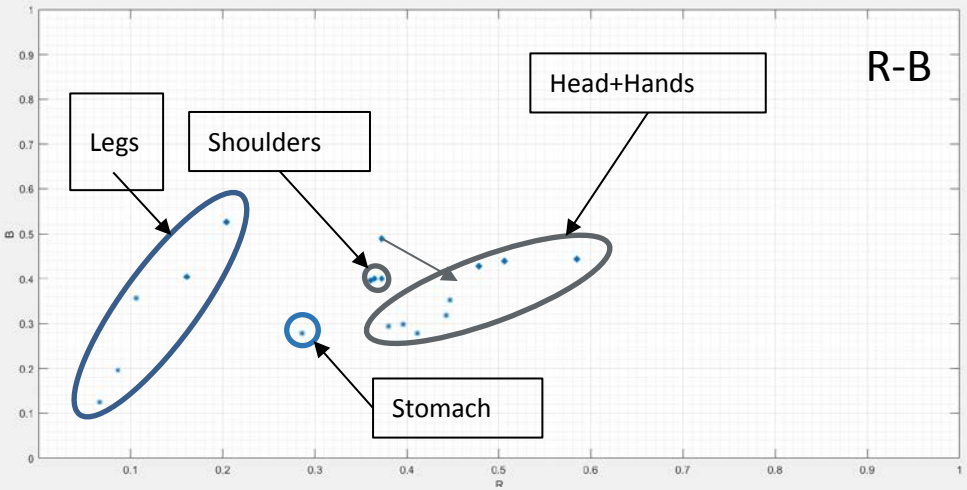


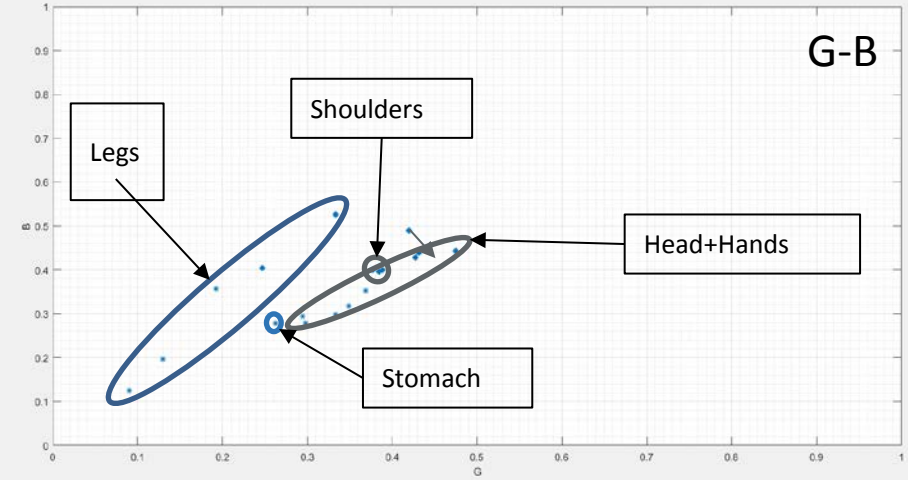
Occupant recordings ID

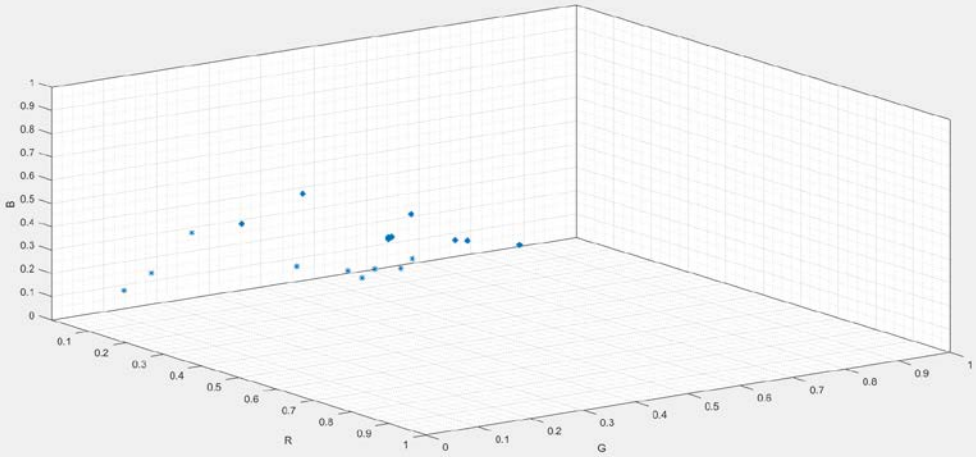

Head
Shoulders
Hands
Stomach
Legs

R G B

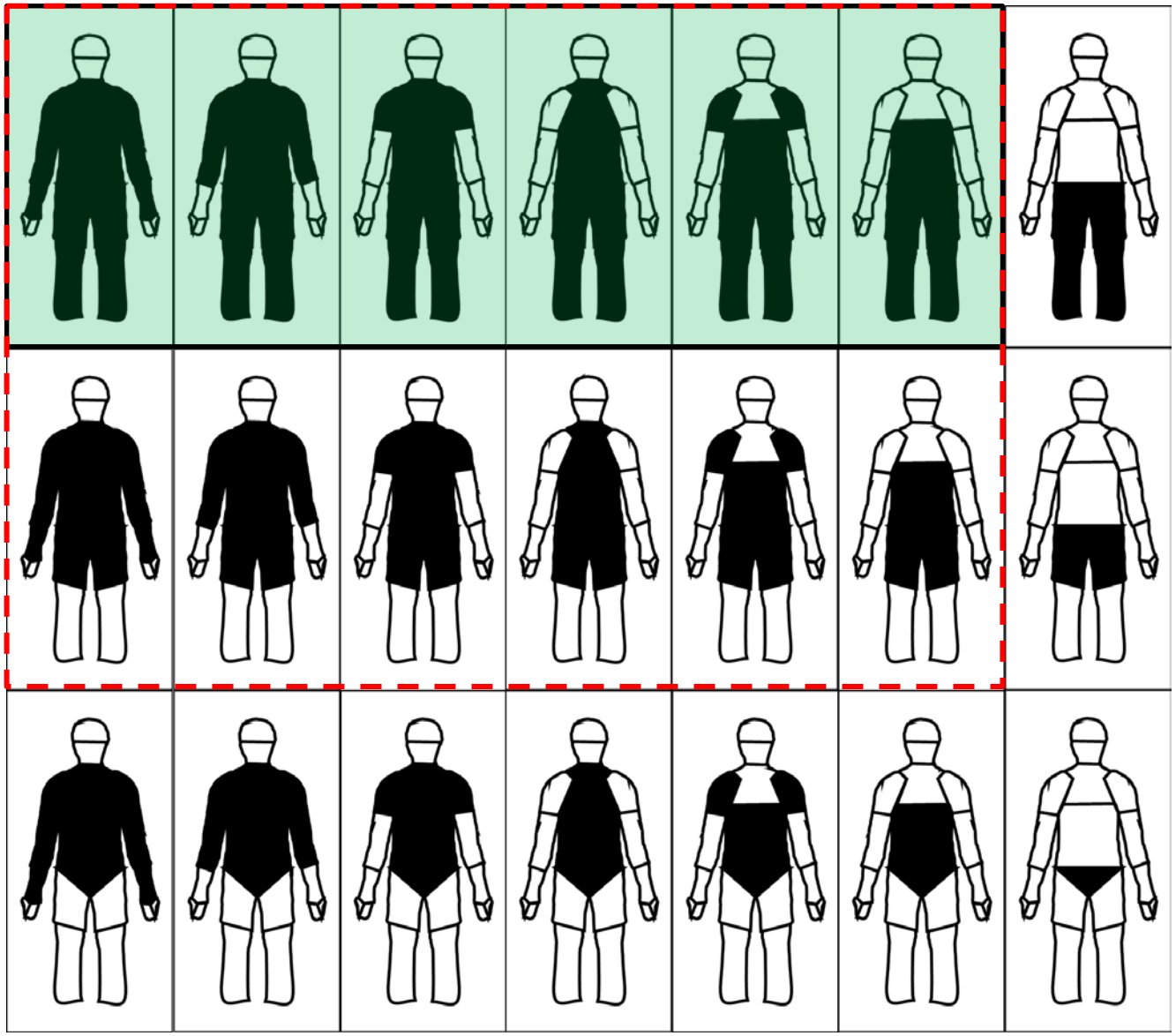

R-G
Head+Hands
Legs
Shoulders
Stomach


R-B
Head+Hands
Legs
Shoulders
Stomach


G-B
Shoulders
Legs
Head+Hands
Stomach



Possible settings

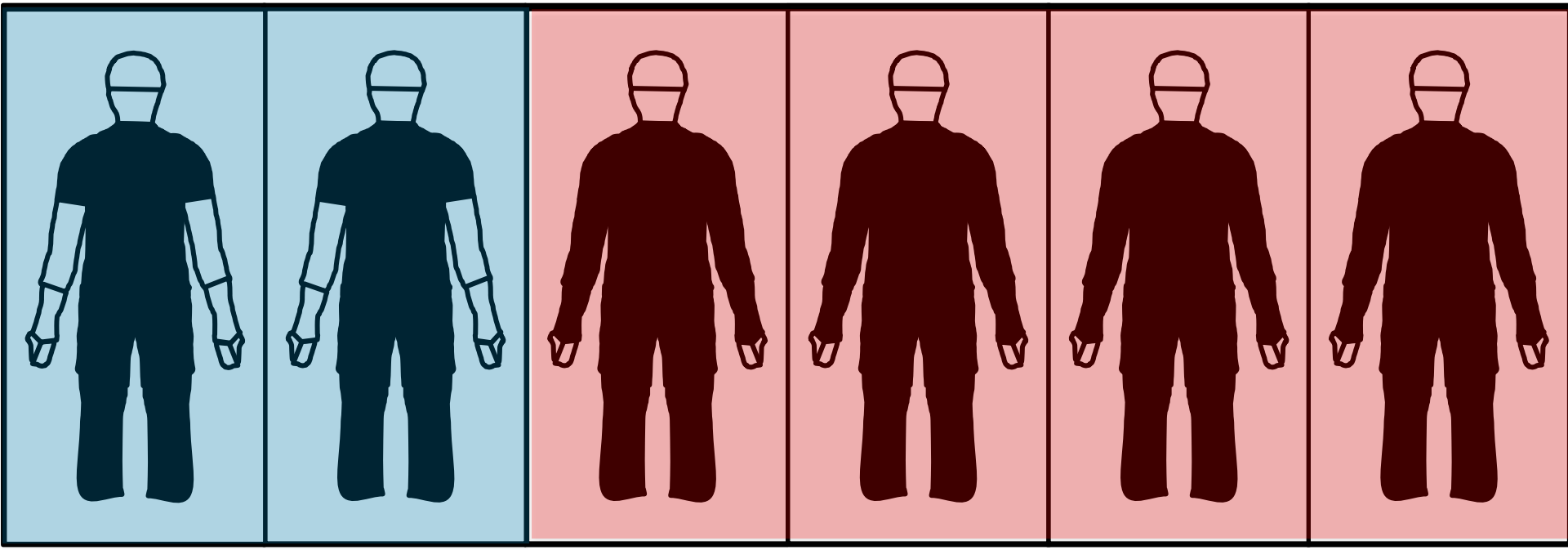


Acceptable for a office type

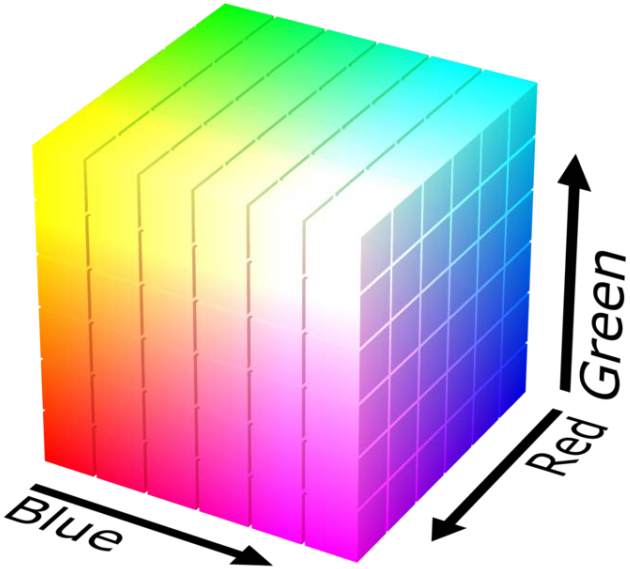
Casual wears

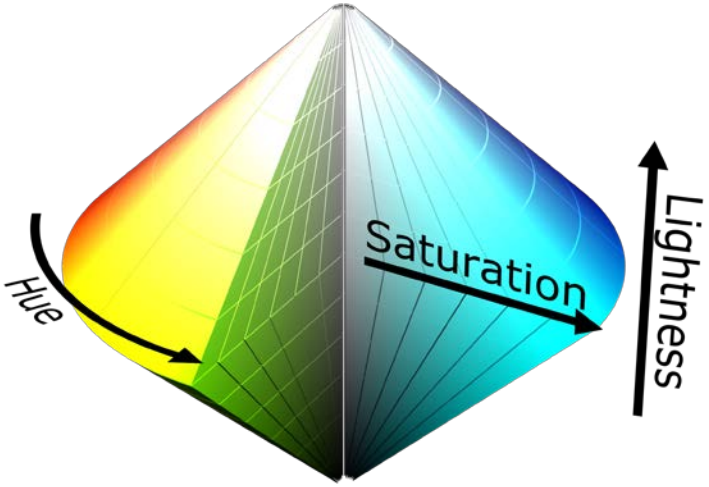
Human skin tone color selection

Casual
Clo: 0,31
Casual
Clo: 0,31
Official
Clo: 0,86
Official
Clo: 0,51
Casual
Clo: 0,43
Casual
Clo: 0,56

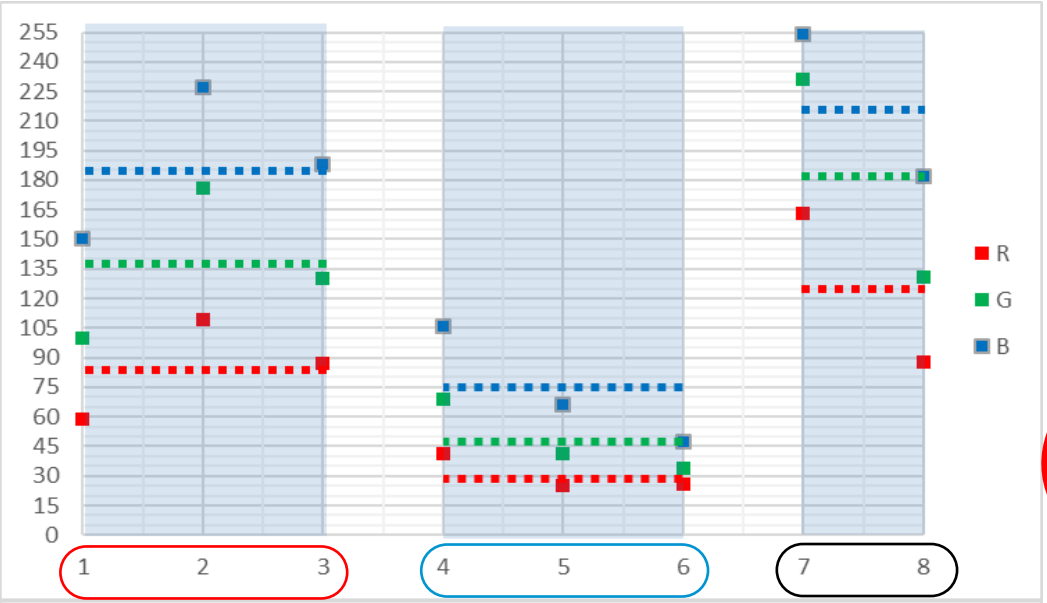


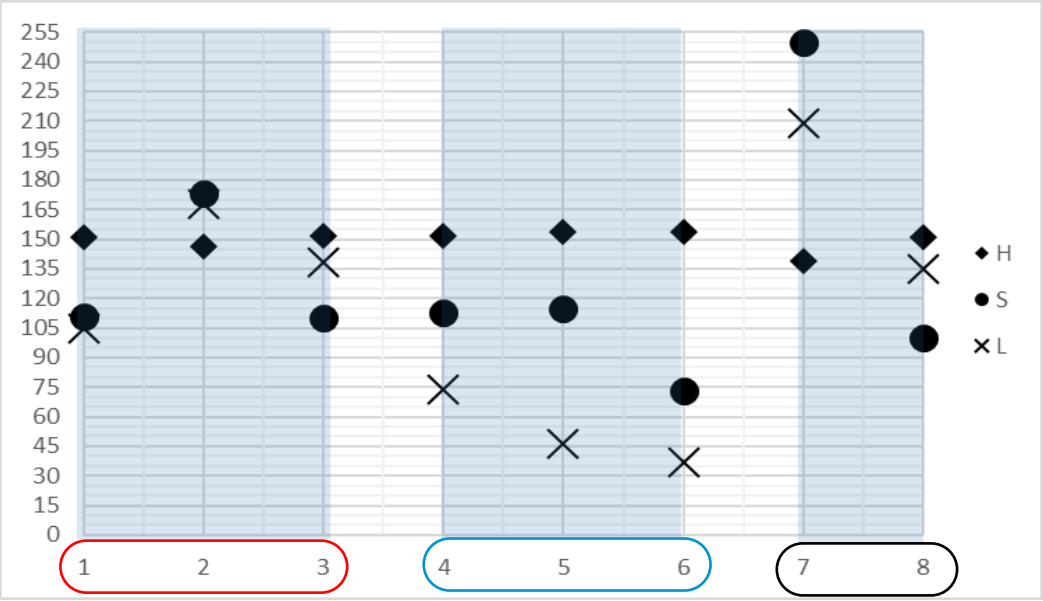
Layers of clothing detection with a use two color maps:
RGB (red, green, blue)
HSL (hue, saturation, lightness)

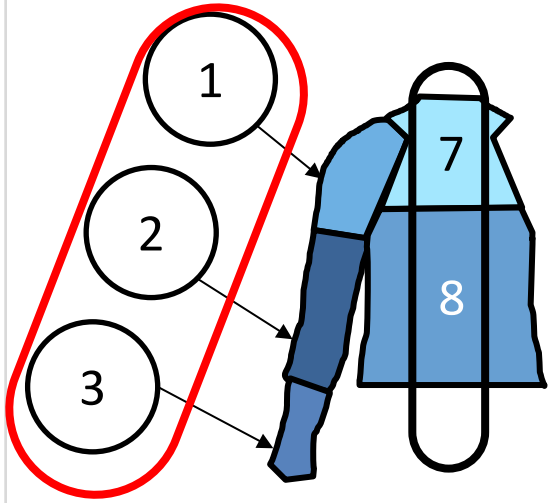


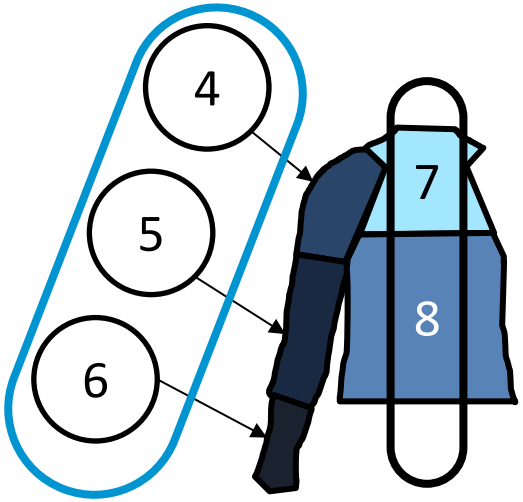


RGB COLOR MAP

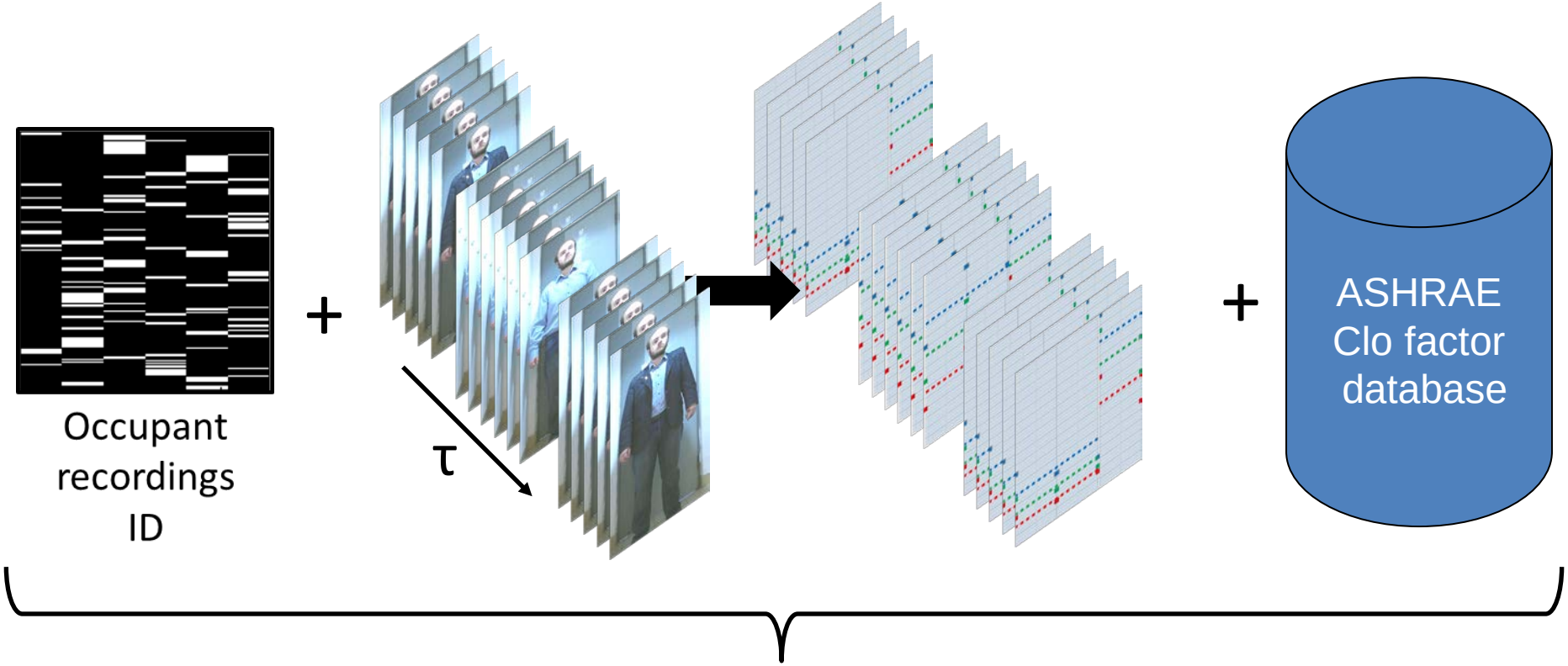


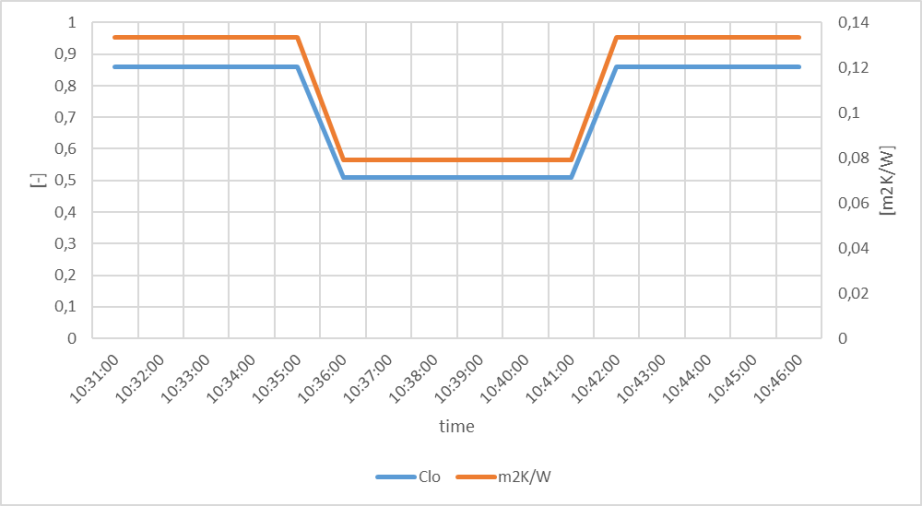






HSL COLOR MAP

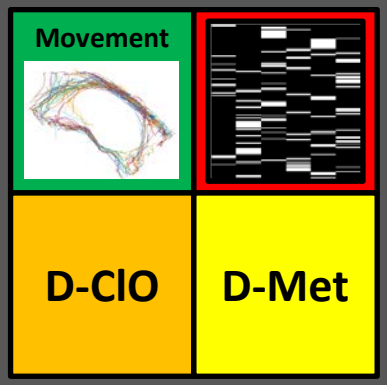

Occupant recordings ID
+
τ
+
ASHRAE Clo factor database


1
0,9
0,8
0,7
0,6
0,5
0,4
0,3
0,2
0,1
0
[-]
0,14
0,12
0,1
0,08
0,06
0,04
0,02
0
[m2K/W]
10:31:00
10:32:00
10:33:00
10:34:00
10:35:00
10:36:00
10:37:00
10:38:00
10:39:00
10:40:00
10:41:00
10:42:00
10:43:00
10:44:00
10:45:00
10:46:00
time
Clo
m2K/W

D-Clo Model

One Day measurement exposition

Occupant monitoring

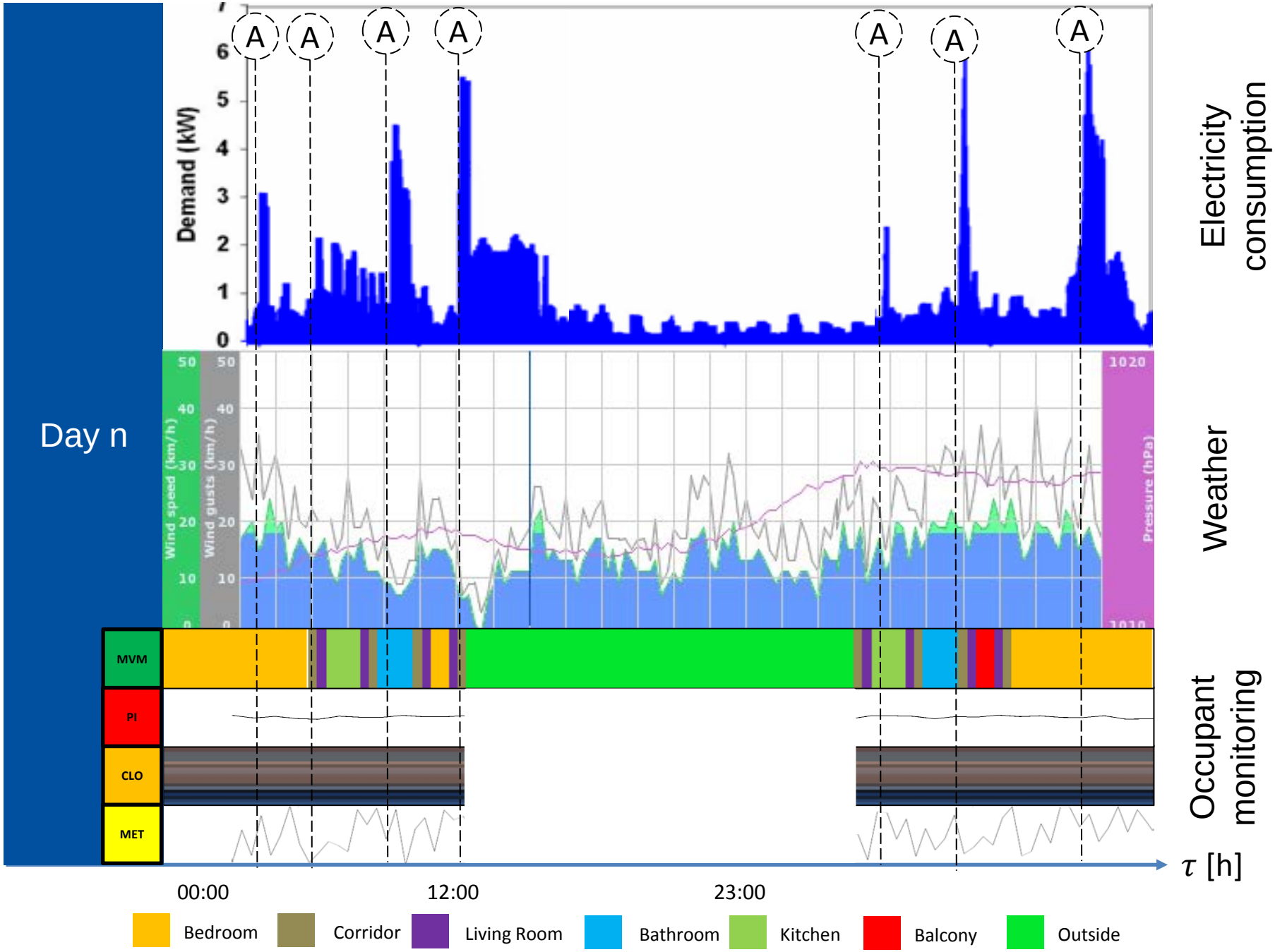


+

Daily energy consumption

+

Daily weather information


Day n
A
Demand (kW)
Electricity consumption
Wind speed (km/h)
Wind gusts (km/h)
Pressure (hPa)
Weather
MVM
PI
CLO
MET
Occupant monitoring
τ [h]
00:00
12:00
23:00
Bedroom
Corridor
Living Room
Bathroom
Kitchen
Balcony
Outside

Thank you for your attention