Fever detection, distance measurement, headcount and group formation analysis using computer vision software Intra to detect SARS-CoV-2 regulation violations.

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Abstract—This paper provides a detailed explanation of a layered data-set that monitors four measures related to Covid19. Keep a distance, do not form groups, don't go outside when you have a fever, and maximum amount of people for events, additionally temperature and humidity in the Kromhouthal are monitored. The measurements are done using a camera setup, from which the images are analysed using machine learning and machine vision algorithms. The data-set consist of four layers to provide different levels of details about the event. The dataset indicates that there are especially to many group formations and distance measurements within the wardrobe, where staff is located. The data is used by behavioral scientist of the University of Amsterdam. Overall people have difficulties complying to the social distancing rules. Trying to influence behavior to improve compliance, with the use of directional guiding arrows placed on the ground, has effect. It marks the success of the waiting stickers used near the entrance. Finally, it is noted that more research is needed to correctly position and configure the thermal cameras to obtain sensible data for fever monitoring without a optical channel.

I. Introduction

Due to SARS-CoV-2 there is a growing need to prevent spreading of viruses. This can be managed by rules imposed by the government. These are different for every country. Here we will review feasibility of four rules active in the Netherlands. Keep a distance of at least 1.5 meters, do not form groups of more then three people, don't go outside when you have a fever [1], and finally the maximum 100 people for indoor events. [2]. Monitoring these rules by hand is quite time consuming. To enable more, and less invasive measurements, Intra realizes this using hybrid thermal optical camera and machine learning techniques.

Additional measurements were made using badges and people registered whether they are part of a family, since these people can walk closely together. It was also investigated if people take more risk while wearing a facemask, which was not the case. Younger people under 18 do not need to keep distance. Measurements for this review are made for the smart distance lab [3], in the Kromhouthal on three consecutive days starting on September 28th and ending on September 30th 2020. Due to the unavailability of optical data to assist the thermal data, as a result of the AVG [4], changes had to made to the data analysis which prohibited Intra from doing the analysis in real-time for this specific event. Since there is a relationship between the spreading of corona-viruses, humidity and temperature measurements [5] are included in the data-set.

II. Setup

In the Kromhouthal, software is used to analyze the video footage. The software used to analysed is an in-house developed framework named Intra. Intra framework is realtime, but also as post-processing, usable using the web-based interface. Intra, itself is Python [6] based. Intra itself uses different hardware components to obtain video footage and environmental data.

A. Hardware

Despite that Intra is a software framework, multiple different hardware components where added to the existing network structure of the Kromhouthal in order to use Intra as shown in Table I. In total six optical power over ethernet (PoE) cameras were mounted on trusses at a height of 12 meters. Two bi-spectral PoE cameras where located on a tripod near the entrance. It should be noted that only the thermal video stream is used. In total two inline power switches and a PoE injector where used to provide power to all eight cameras. In the control room, a pc with GPU, was installed which processed the video footage in realtime using Intra. In this control room a Netwerk Video Recorder (NVR) was installed too. This NVR is used to capture all video footage of the 8 cameras. In the control room an extra WiFi router was installed to provide the environmental sensor with wireless internet access. This router provided also the extra Ethernet ports needed. The environmental sensor was installed at the art fair exhibition at 2.5 meters height.

B. Architecture

The previously in table I noted components are linked to each other as described in the network diagram as shown in

TABLE I: Hardware components in SDL analysis

N	Component	Location	Relevant specifications
6x	Optical camera	Truss art fair	PoE, 1920*1080

2x	Bi-spectrum camera*	Tripod entrance	PoE, 1920*1080, 384*288
2x	Switch 8 ports	Control room	4x PoE out
1x	Router 4 ports	Control room	802.11n, 1Gbit/s
1x	NVR 16 ports	Control room	2TB storage
1x	Server machine	Control room	i7, DDR5 32GB, 4352CC**
1x	Ubibot WS1	Art fair room	802.11n, battery
1x	PoE injector	Server room	-

* Only thermal spectrum is used, ** CC, Nvidia CUDA Cores

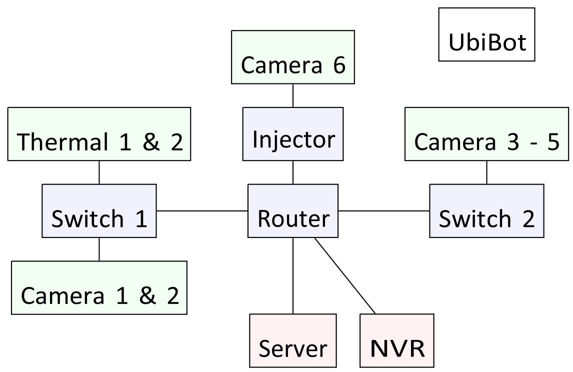


Fig. 1: Network diagram used in the Kromhouthal for SDL.

fig. 1. Note that the data flow starts from the cameras, marked in green, towards the processing units, marked in red. It flows both ways in the network components as marked in blue. Intra software architecture is shown in fig. 2. The stages of enriching the data are described in in the data-flow section. Stages in the model are default layers within Intra's core software component.

C. Data-flow

During this research, multiple levels are used to describe the processed data. This layered structure makes it clear, what could and could not be concluded from the data as well as in what way the information already is processed. An hierarchical structure is used whereby each layers serves as an input to the next layer, but increases the abstraction of the data. In total there are four layers as shown in fig. 3.

1) Layer 1: This layer contains the raw video footage captured during the exposition. This data is unprocessed and could be inspected by the human eye. In this layer, people could be followed over multiple camera shots by syncing by hand. This is comparable to a security officer inspecting the camera footage.

2) Layer 2: This layer provides the first level of abstraction from the raw video footage. Computer vision is used to obtain pixel coordinates of people passing by. In this layer also the data of multiple cameras are merged into one single data-set with removal of data-points at the overlap of view. The pixel coordinates obtained from this layer could be converted to physical coordinates

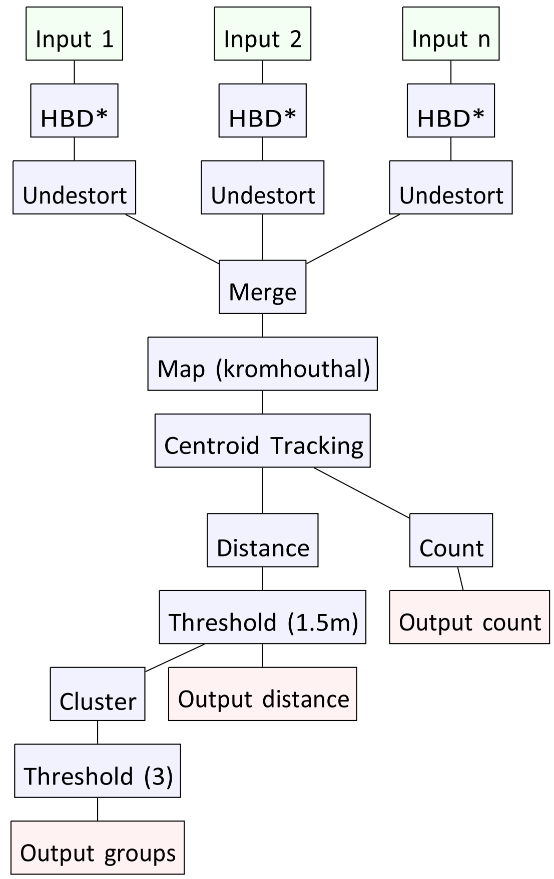


Fig. 2: Intra model for top view detections: visitor count, distance and groups. *HBD = Human blob detector.

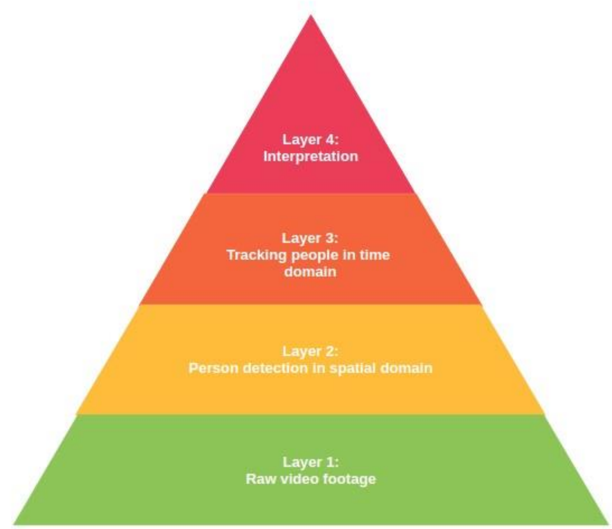


Fig. 3: The abstractedly and dependency of the layered structure of the data could be represented by a pyramid. Every layer is dependent on the layer before, but increases the abstractness of the data.

(a) Two cameras before merger (b) Full merged camera view

(b) Fig. 4: Camera view before and after merge.

3) *Layer 3:* This layers adds as extra abstraction the time spatial information to the data. Tracking algorithms in combination with filtering are used to provide data-points whereby time gaps are reconstructed and noise in the spatialtime domain is removed.

4) *Layer 4:* In the last layer the data is further processed to make conclusions about the effectiveness of the measures taken to prevent spreading of the SARS-COV-2 virus. Addi-
tionally, a few improvements to these measures are proposed.

III. Methods

A. Point representation

To be able to efficiently analyse the behaviour of the visitors to the Kromhouthal the visitors will be represented as x,ycoordinates in the following layers. This is done in five steps; removing distortion, human detection, data merger, tracking and filtering.

To remove distortion all six cameras are calibrated individually, these calibrations are then used to create conversion maps to compensate for lens distortion [7].

Secondly humans are detected within the frames, the six topview cameras use the Intra Bird-view layer. The data is now represented for each camera individually (fig. 4(a)). Using the Intra Merge layer the data of of the individual cameras is put together by translating the points on the x, y and z axis, rotating around the z axis, and combining (semi-)overlapping points (fig. 4(b)). Simultaneously a map representing the walls in the Kromhouthal is added. These walls are later used to prevent distance detection from measuring through walls and improve visualizations (figure 6).

In the next step the points are tracked over time using a vectorized interpretation of the Sigma point Kalman filter [8], creating ca. 33k person identifications.

Finally the data is filtered on false positives, and false negatives. False positives are removed, false positives are defined as detections that are detected that exist for less than eight seconds. False negatives are added by interpolating the data. If detections for a identification are missing and a maximum of ten seconds apart, the missing detections are added using the linear average of the closed two detections. The combination of these filters reduces the amount of identifications to 30k. This is 10-15 times as much as the total amount of visitors that visited the event, meaning that the average visitor walked in and out of sight of the cameras 10-15 times, since walking back into view assigns a new id to an visitor.

B. Headcount

Continuously is the number of people monitored that is in between the entrance and the end part of the exhibition. The lower of part of the people in the exhibition is excluded as well as people that is out sight of the cameras, due to using the restroom. At each frame, the people detected are defined as set P:

$$P = \{(x_1,y_1),(x_2,y_2),...,(x_n,y_n)\} \quad (1)$$

, where each person i is at location (x_i,y_i). The total-number of persons in the set is n. The headcount is equal to the totalnumber of persons. The headcount is calculated as a function of time t.

C. Distance monitoring

For distances monitoring between people, the euclidean distance given by equation:

$$d = \quad (x_1 - x_2)^2 + (y_1 - y_2)^2 \quad (2)$$

where $(x_i,y_i)_{i=1,2}$ is the location of the person, is used. The distance d is the distance between two points in pixels. Since the cameras are undistorted, all points are represented at ground plane. This results in a constant factor to scale from pixel distance to real distance. The distance d is multiplied by constant factor k, 5.5, to scale to a metric distance. When the distance d is smaller than 1.5 meters, the distance detection is saved and labeled.

However, this results in defections which are still allowed. People are allowed to stand closer than 1.5 from each other when a wall, Plexiglas safety screen or anything comparable is in between. Detections where the minimal distance between two persons at locations $(x_i,y_i)_{i=1,2}$, line u, could not preserved, are removed when any of the walls as defined in the map is in between. Walls are defined as a line w between points $(x_i,y_i)_{i=1,2}$. In other words, u is valid when it does not intersects with any w.

Note that these detections also include people from the same household, and under 18 years old, while in reality these people are an exception and not actually count for as a detection. Additionally, it should be noted that the duration of the detections was not taken into account. The duration of some detections is only a few seconds, while the actual detection should persist for at least 15 minutes [9] [10].

D. Monitoring group formation

Groups are defined as a set of visitors having n connection with a distance d ¡ D to other visitors. Where $n >= 3$, which are

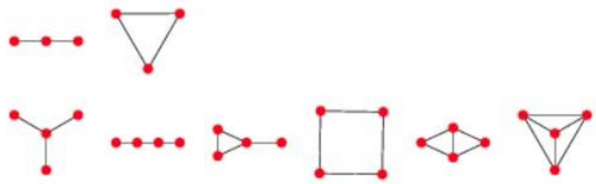


Fig. 5: A subset of examples of group formation detections.

E. Fever monitoring

the minimal number of people and D = 1.5 with D in meters. The distance d is as defined in section III-C. The range for n starts at 3 because, when n is less, group formations detection is the same as a normal distance detection.

To clarify the definition, a subset of detections are shown in fig. 5. It is shown that a detection of group formation is a connected graph with n nodes. The edges in the graphs represent the distance $d < D$. As shown in the figure, not all nodes are connected to two or more other nodes directly. A group formation is a cluster of connected nodes.

At first person are detected by using a neural network based on Mobilenet [11]. This network is retrained on the FLIR dataset [12] and adapted to perform better on short distance. The detected humans are used as input to the Intra Thermal module, where an estimate is made where the head is located. In this process it is assumed that the head is partly located in the upper one sixth part of the detected human. Using the thermal information provided by the frame and the pixel values, an temperature is obtained. Some filtering is applied to remove extreme temperatures for the human body.

F. Temperature and humidity

During the event, continuously the temperature and humidity is monitored using a Ubibot WS1. This device is used to measure the environmental parameters of the Kromhouthal over time. The device measures information about humanity, temperature, vibrations and light conditions with its internal sensors. Other environmental probes as well as second temperature probe could be connected to the device but is not used. In this research topic only temperature and humidity are well known factors that influences the spreading of the SARSCoV-2 virus. The internal temperature sensor has a precision of ±0.3°C and a range of -20°C to 60°C. The internal humidity sensor has a precision of ±3RH within the range of 10% till 90% relative humidity. The environmental conditions are sampled at an interval of 5 minutes at a approximate height of 2.5 meters from ground level.

IV. Results

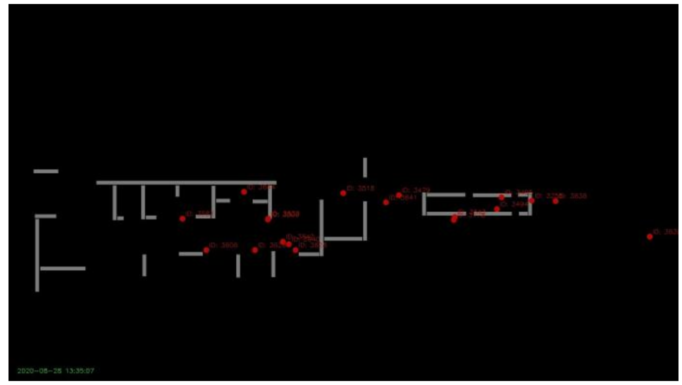


Fig. 6: Visualisation of layer 3 point representation on the floor plan of the Kromhouthal.

A. Point representation

The point representation of a frame is shown in fig. 6. As visible in the figure, every person is represented as a point on the floor plan of the Kromhouthal. The numbers next to each points represent the tracking ID. This unique tracking ID shows relevant information in the time domain. From this information, layer 3, violations of the disease prevention regulations are obtained.

B. Counting visitors

During the event the amount of visitors simultaneous in sight of the camera setup varies between 0 and 40 visitors as shown in fig. 7, with an overall average of 8.8 visitors. This average increases to 18.9 when only the event itself, from the arrival of the first person to moment the last person leaves, is

Fig. 6: Visualisation of layer 3 point representation on the floor plan of the Kromhouthal.

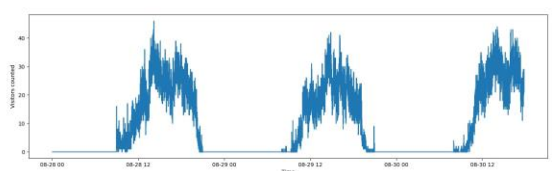


Fig. 7: Number of visitors in the Kromhouthal over time.

taken into consideration.

To visualize popular locations a heat-map is generated of the most active locations as shown in fig. 8. From this three things can be concluded. There is a increased preference for visitors to stand at the corners of walls, fig. 9(a). Secondly, there is a high concentration of person detections in the wardrobe, fig. 9(b). This could be traced back to the fact that at all times, multiple volunteers of the exhibition were present in the wardrobe. And lastly, the effectiveness of the 1.5m distance stickers on the ground near the entrance are visibly effective, fig. 9(c). This is conducted from the fact that there is not a line of detections of people, standing randomly still at different places in the line but that spots highlight in a grid manner. Since this stickers are placed equally distanced far enough apart to prevent people standing with less than 1.5 meters in between, this measurement ensures people keep distance while waiting.

C. Distance monitoring

The distance that visitors keep to each other in the Kromhouthal has been monitored for both 1 meter and 1.5 meter minimum distance, see fig. 10. The number of occurrences

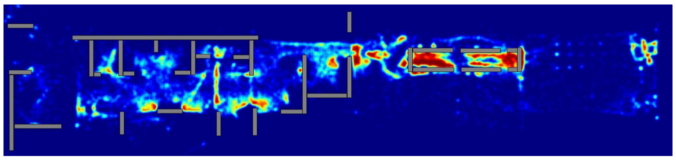
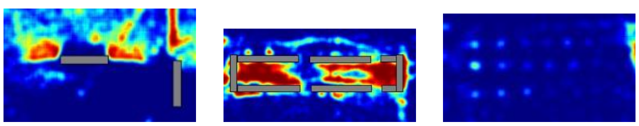


Fig.8: Visualization of most active location in the Kromhouthal.



(a) Corners (b) Wardrobe (c) Stickers

Fig. 9: Selection of relevant observations in the visualization of most active location in the Kromhouthal.

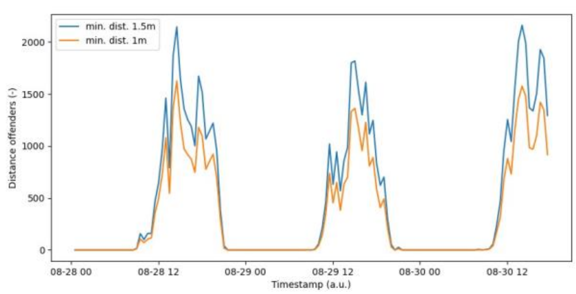


Fig. 10: Number of occurrences where minimal distance of 1 meter and 1.5 could not be preserved in the Kromhouthal against time.

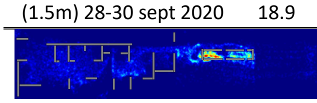
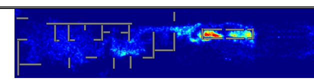
where minimal distance of 1.5 meter could not be preserved, are grouped in groups of 30 minutes. Measurements range from 0 to 2151 distance offences per 30 minutes when the minimum distance is set to 1.5 meters. When set to 1 meter the upper range limit reduces to 1604. With an average of 935 offences per 30 minutes. In table II this data is combined with the previously obtained visitor count to obtain an average amount of distance offences during a visit of 30 minutes. Overall this results in 49.5 distance offences per visitor per visit.

To get more insight in when these events take place a heat-map for all three days for both 1 meter and 1.5 meter is included in fig. 11(a)(c)(e) and 11(b)(d)(f) respectively. Here, there are two things that stand out. Firstly, there are a few lines that is that become more vivid when the distance is set to 1 meter. The assumption is that this are couples, this however is not confirmed. Secondly, in both cases, 1 meter and 1.5 meter, there is a clear decrease in distance offences for the volunteers in the wardrobe from September 28th to 30th.

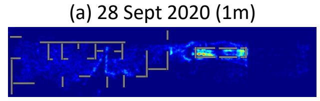
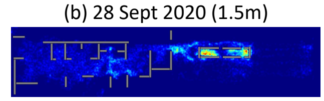
Check uitlijning

TABLE II: Distance offences per person

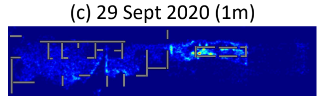
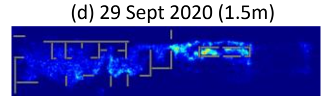
Day	Avg. visitors	Avg. offenc es per 30 minutes	Avg. offe nces per person
(1m) 28 sept 2020	18.0	682	37.9
(1m) 29 sept 2020	16.8	501	29.8
(1m) 30 sept 2020	21.8	844	38.7
(1.5m) 28 sept 2020	18.0	949	52.8
(1.5m) 29 sept 2020	16.8	691	41.1
(1.5m) 30 sept 2020	21.8	1164	53.4
(1m) 28-30 sept 2020	18.9	676	35.7
(1.5m) 28-30 sept 2020	18.9	935	49.5

(a) 28 Sept 2020 (1m) (b) 28 Sept 2020 (1.5m)

(c) 29 Sept 2020 (1m) (d) 29 Sept 2020 (1.5m)

(e) 30 Sept 2020 (1m) (f) 30 Sept 2020 (1.5m)

Fig. 11: Heat map of locations where the minimal distance could not be preserved in the Kromhouthal.

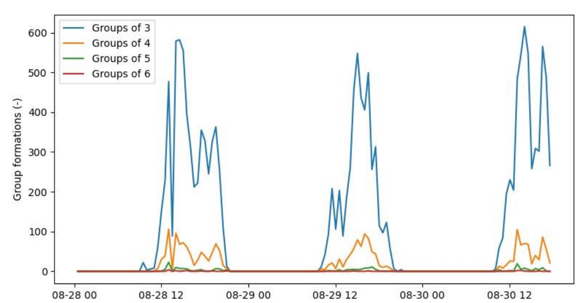


Fig. 12: Number of group formations with size between 3 and 6 visitors in the Kromhouthal against time.

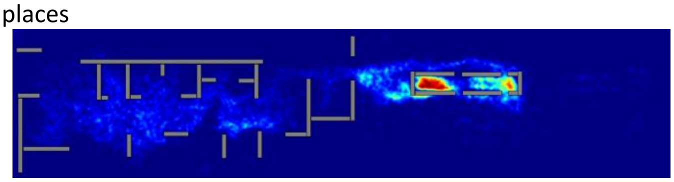
D. Monitoring group formation

For different group sizes n an analysis have been conducted. In the case of the Kromhouthal the maximum n for which violations are detected is 6. During the event no groups containing 7 or more visitors are detected. In the visualization the detections are grouped in segments of 30 minutes. This is shown in figure 12.

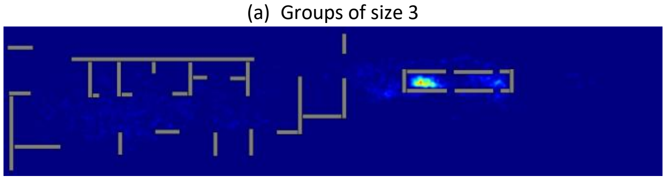
For each group size there is a different range of number of violations. The range for groups of 3 people occur 0 to 614 times per 30 minutes. The upper bound of this range changes for groups of 4, 5 and 6 to 104, 19 and 4 detections per 30 minutes respectively. Hence, groups get 5x smaller when the group size n increased by one. The four situations are visualized in figure 13.

What could be concluded from fig. 13, maintaining distance while working as volunteer in the wardrobe is hard. Not in the part of the wardrobe itself but especially at the place of reaching out and gathering the forms and other tracking devices of the Smart Distance Lab. It could be that during this process the 1.5 meter is not maintained. Another explanation could be that these volunteers are standing close to each other while having a conversation.

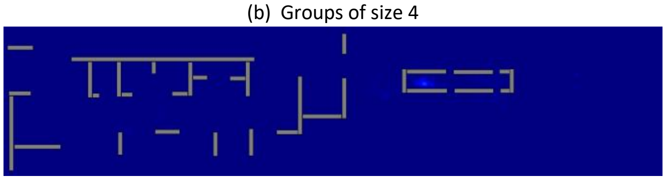
From fig.13(a) also the walking patterns could be recognized. These map also indicates where people are crossing over from one side to another. It highlights also the places



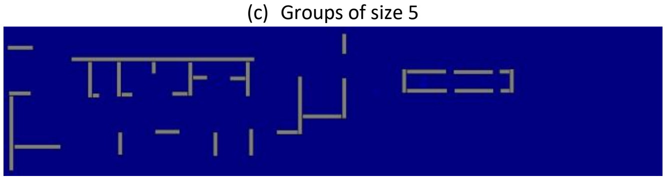
(a) Groups of size 3



(b) Groups of size 4



(c) Groups of size 5



(d) Groups of size 6

Fig. 13: Visualization of most group formations in the Kromhouthal.

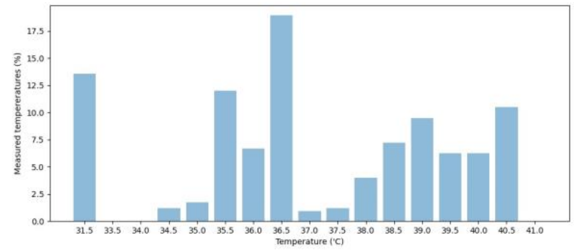


Fig. 14: Percentage of temperature measurements of people in lanes.

which narrows down to a smaller hallway.

E. Fever monitoring

During the event the highest temperature measured for a person in a lane was determined. In fig. 14 a visual representation of how often each temperatures is measured. In total there where 32026 measurements conducted in a range between 31,4°C and 40,9°C, averaging out at 36,9°C. Despite the seemingly accurately average this temperature data is not accurate enough to draw conclusion from. This is confirmed by the notion that the temperature, T, has 13463 detections where a fever is detected, $T \geq 38$°C. And therefore accounts for 42% of all detections, which is too often.

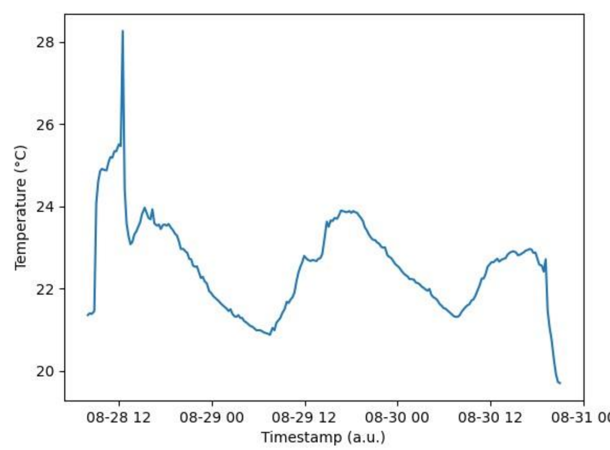


Fig. 15: Temperature in the Kromhouthal during the exposition.

F. Temperature and humidity

During the exposition the temperature was between 20°C and 25°C as shown in fig. 15. An higher temperature has be shown to increase the inactivation rate of the virus [5]. For humidity however it is shown that the optimal inactivation rate is at about 50% humidity [5]. The humidity in the

Kromhouthal during the research is as shown in fig. 16 to be around 56%. Despite that the environmental factors in the Kromhouthal had a positive effect in decreasing the survival time of the virus, it should still be concluded from previous work that the virus survived for at least 3 days on surfaces [5]. However, there is no prove that the virus still is contagious after those 3 days. In addition, the Kromhouthal was cleaned about once an hour with a air fogger ?? to reduce the chance of spreading of the virus during the event. No further research was conducted during the event about the survival of the virus outside the human body. No infections were reported during the event, which involved approximately 1,200 visitors. What should be noted is the spike in temperature at the morning of 28st of Augustus. This is due to the heat from the hands of the person re-positioning the Ubibot.

V. Discussion

A. Tracking and detection

The algorithm used to provide the spatial coordinates of the persons visiting the exposition has a number of limitations. The detection algorithm is based on a moving object against a stationary background. Due to Ethernet throughput limitations, it is possible that there was a temporary loss of camera resolution. This result in a reloading of the background in lower resolution. The reloading of the background results in false positive defections of moving objects.

The algorithm is also limited by the limited possibility of separating different objects that are close to each other.

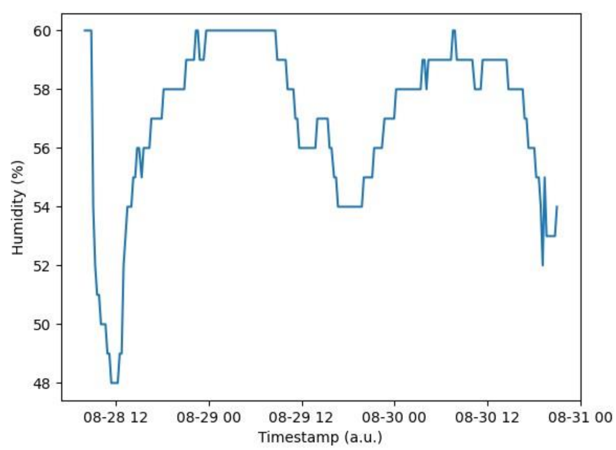


Fig. 16: Humidity in the Kromhouthal during the exposition.

Although multiple filters are used to reduce that two objects are merged into one, it could not always be prevented.

As third limitation, the software had to be robust to objects that were moved around in the exhibition. By assuming that long still standing detections where not human, objects were excluded from the measurement. However, people that were for a long time being on the exact same spot where noted as objects part of the exhibition. When those people start moving again, Intra registered them as a new person.

The fourth limitation during tracking of people was not covering the complete Kromhouthal. People could enter spaces of the exhibition as well as the public bathrooms without being recorded by any of the six cameras. This lack of coverage resulted that people could vanish from the map and reappear after an undefined moment of time. The algorithm used was optimized for detecting people, however not to re-identify people. People who where outside the camera coverage, where assigned a new identifier when they were inside of view again. This resulted in many more unique identifiers compared to visitors of the exhibition. However this ensures the privacy of the people visiting the art fair.

In order to improve the detection of people on camera footage a more robust algorithm could be used. Integrating a trained convolution neural network (CNN), focused on tracking not object detection, could be used as alternative for the method used in this paper. However CNN are more computational heavy. In the ideal case this CNN is also able to reidentify people which are temporarily out of view of the cameras. The state-of-the-art networks of re-identification are still heavily under investigation by companies like NVIDIA [13].

B. Distance

As defined by law, a violation of the minimal distance of 1.5 meter is already a violation when somebody is passing. However it could be discussed if these short interactions are enough to transfer the disease to another person. In further experiments, it is proposed to investigate the effect of such short interactions on the outcome of the experiment. In the follow up it is proposed to investigate how the heat map is changed by excluding this short interactions. However researching only this short interactions could potentially show more information about where size of the walk-troughs are the limiting factors. As next research, the proposal is measuring the violations with following parameters: > 1 min contact < $1.5m$, > 1 min contact < $1m$, > 5 min contact < $1.5m$, > 5 min contact < $1m$, > 10 min contact < $1.5m$, > 10 min contact < $1m$. For conducting more research on the walkthrough it is proposed to only consider violations < 5 seconds with a distance of < 1.5 meter.

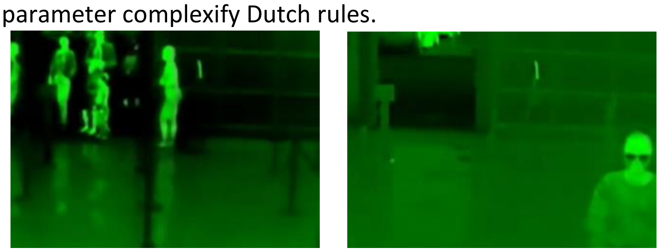
A follow up question raised by the question if we should exclude short term interaction is: 'Should we count two separate interactions between two persons as two times the distance could not be maintained if the time between them is a small period?'. To illustrate the hypothetical situation were this is relevant an example is given: Two persons are having a conversation with each other, while one person moves a bit forward and back. During this moment, are the two persons excluded for a short period of time from one long interactions or are these both two short interactions. At this moment it is accounted as two short interactions. This same effect is happening in this research. When does a short interval of interruption of not maintaining a minimal distance count and when does it not? A clear boundary should be provided to re-investigate the number of times the minimal distance could not be preserved.

Every person is allowed to exclude one other person, from which a minimal distance should be preserved. This makes it possible to walk as couple through the exhibition. However the software itself is not able to detect who is a couple with who. This results that people who are walking around as a couple are allowed to not comply with the minimal distance which they should be apart. In the ideal scenario, this data would be available and could be used by Intra to reduce the number of false positive violations.

C. Groups

For prescribed maximum group size, two comparable scenarios occur as prescribed in section V-B. The first case is the short group formation of three people by accident due to an individual passing by a couple as example. The second case of group formation that could be happening is the example of a household. By Dutch rules it is allowed that a household walks together as group. Another example in which false positive are detected are the case with children. Children are allowed to gather together when they are under a certain age. However on the video footage it is not possible to label any detection of a human as a child.

For revision of the regulation of the maximum group size, it is proposed that further research is conducted to the influence of the minimal time a group is together before it is noted as a violation of the regulation. However it is noted that time parameter complexify Dutch rules.



(a) Incorrect distance (b) Correct distance

Fig. 17: Frame from a situation where the correct and incorrect distance to the thermal camera is shown

D. Fever detection

As concluded in the results the fever detection is not reliable enough. Two causes for this inaccuracy are the positioning of the thermal camera. And the lack of optical data to determine the position of faces.

The positioning of the thermal cameras would be better if the cameras would be located between one and two meters lower since, inaccurate temperature measurements occur mostly at a distance, fig. 17(a). This yields two problems, a lack of details in the thermal image, resulting in too little pixels to determine the temperature accurately. And secondly, a loss in accuracy due to distance itself [14].

Additionally the software can be improved by detecting thermal faces directly, instead of the current method where first a full person is detected and within this person there is searched for the location of the face. To improve accuracy further, the threshold for the minimum amount of used pixel can be increased. The combination of these two methods might resolve the problem of the missing optical data, further research to confirm this is required.

VI. Conclusion

In this paper, multiple methods are presented in which Intra measures the effectiveness and the number of violations of different SARS-CoV-2 transmission prevention measures. In keeping distance it is shown that narrowing hallways are the places where congestion occurs. Narrowing the hallway by making two one-way lanes leads to more occurrences where the minimal distance could not be preserved than in a oneway lane all around the exhibition. However it shows a little more effective than no walking route at all. Besides the arrow stickers placed on the ground, it is shown that waiting stickers in queues are effective at stimulating people keeping distance by influencing where they will stand still. Waiting stickers, which enforce enough distance are therefore encouraged to be used. One-way pathways are also a rule that makes it easier for people to comply. The majority of the occurrences where the minimal distance could not be maintained, volunteers where involved. Attention is needed for the design of the workspace for events to improve on this. Overall people have difficulties complying with measures at all times.

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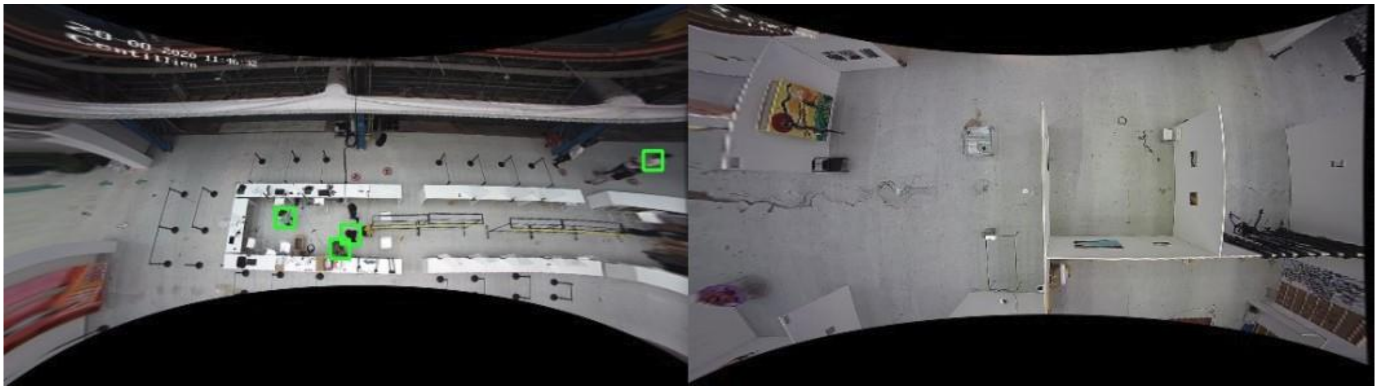
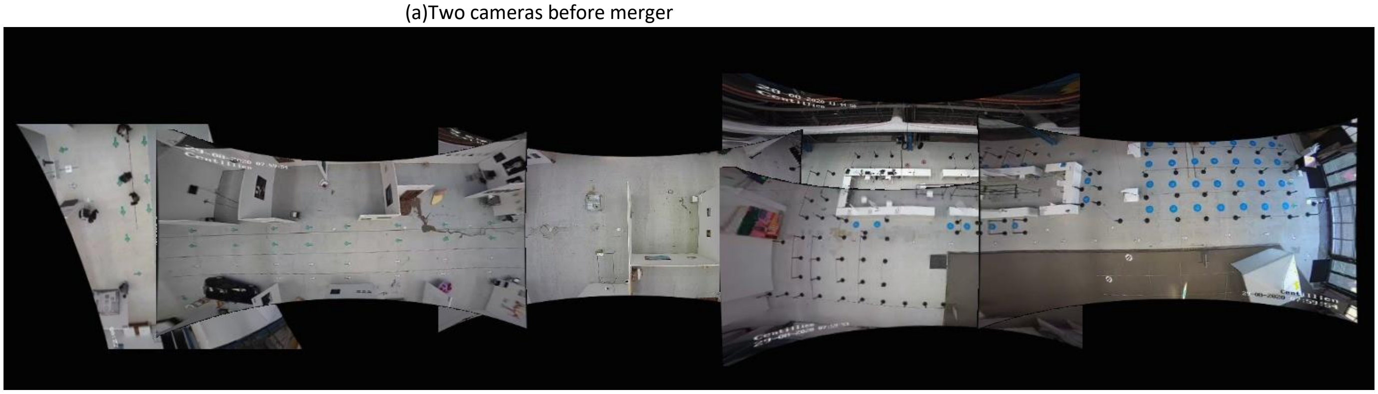
APPENDIX

A

FIGURE 4(A)(B)



(a)Two cameras before merger



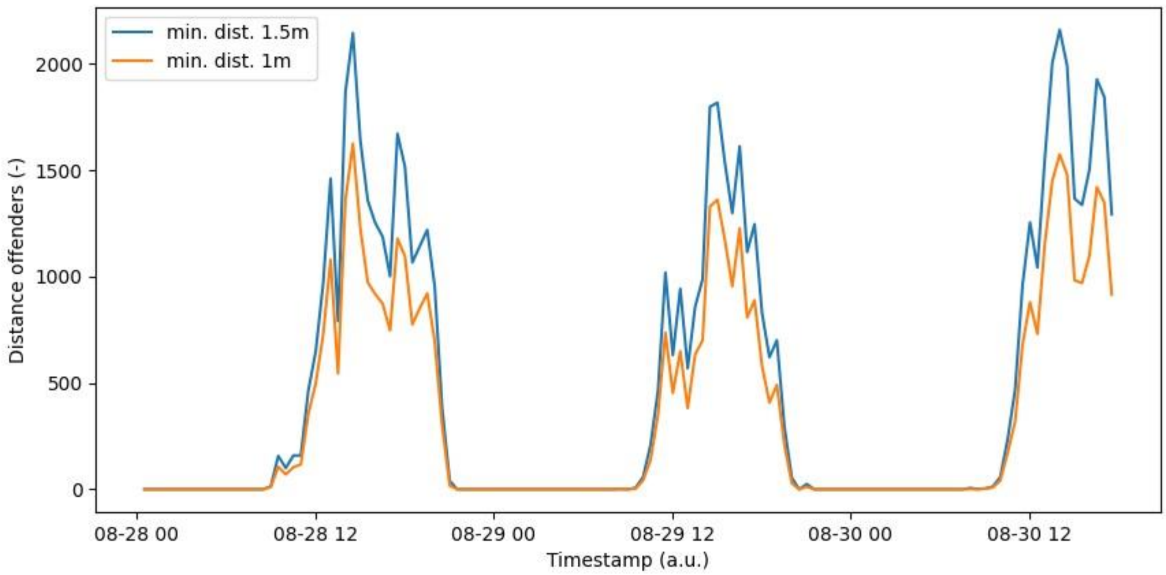
(b) Full merged camera view

(c) Camera view before and after merge.

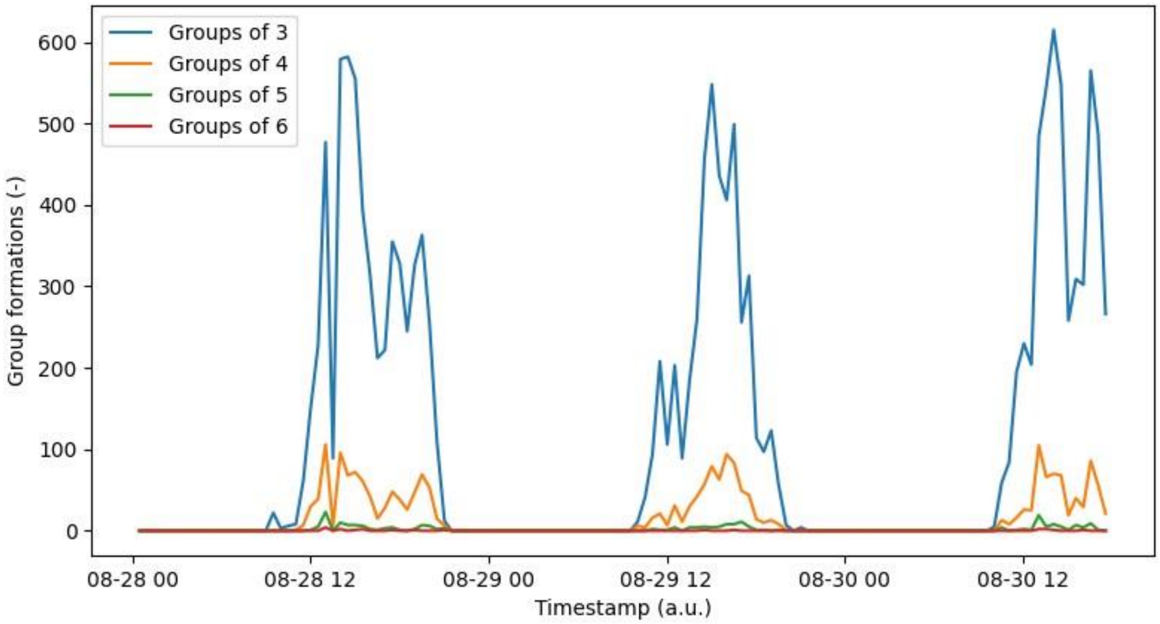
B

10

FIGURE

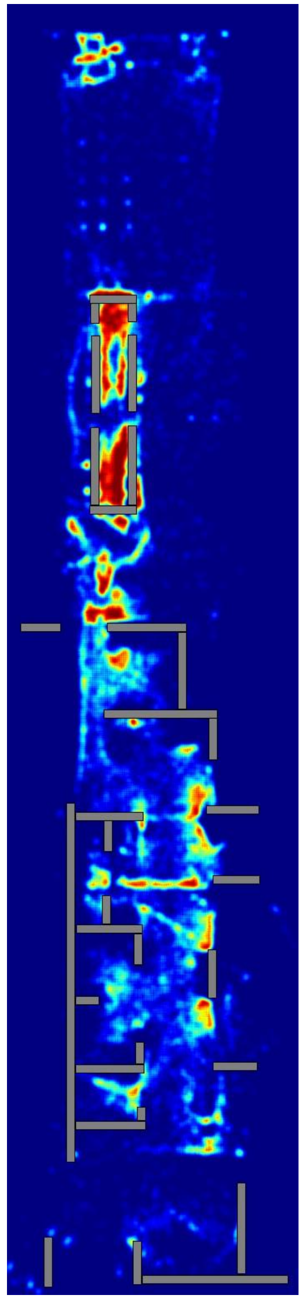


Distance offenses for 1 meter and 1.5 meter in the Kromhouthal against time.



Number of group formations with size between 3 and 6 visitors in the Kromhouthal against time.

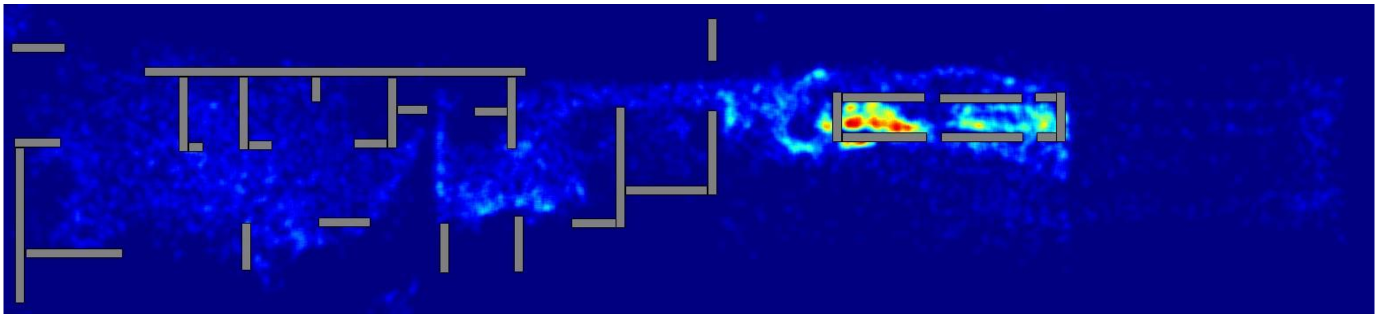
APPENDIX
FIGURE
D
8



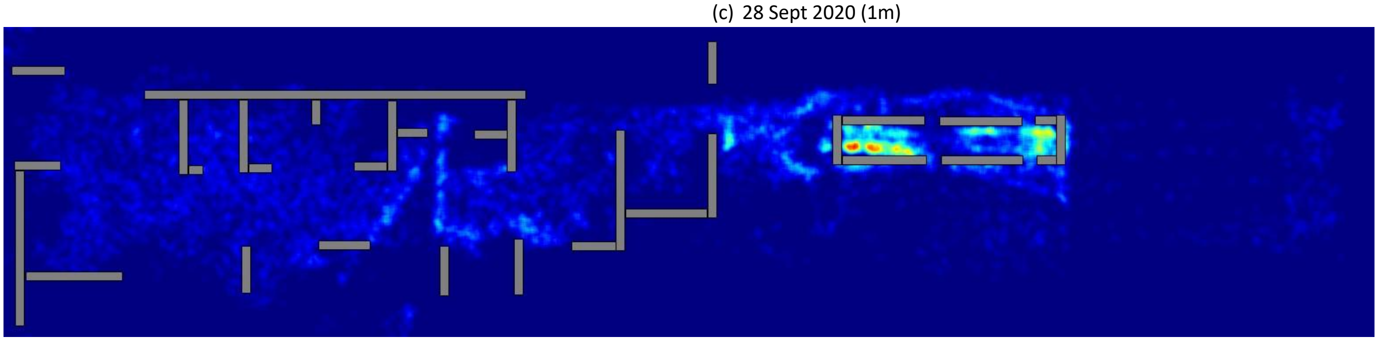
Visualization of most active location in the Kromhouthal.

E

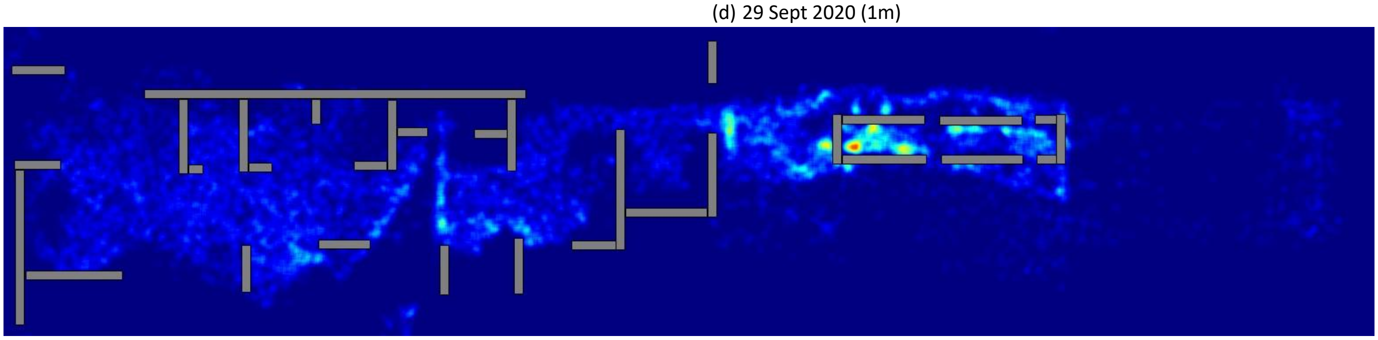
FIGURE 11(A)(C)(E)



(c) 28 Sept 2020 (1m)



(d) 29 Sept 2020 (1m)

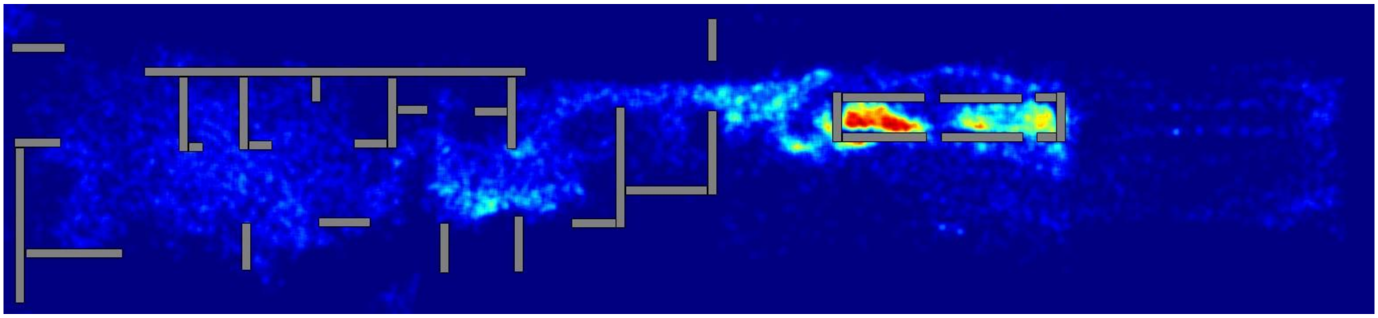


(e) 30 Sept 2020 (1m) Visualization of

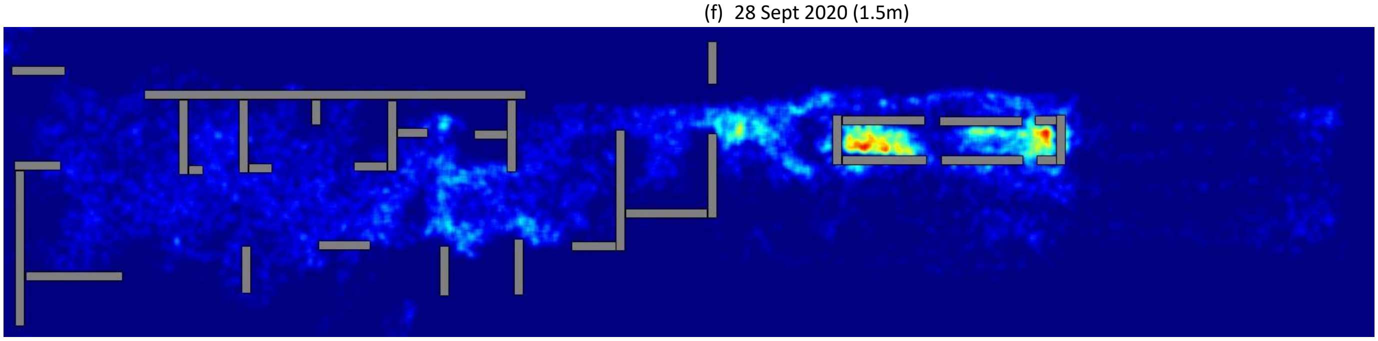
most distance offences in the Kromhouthal.

F

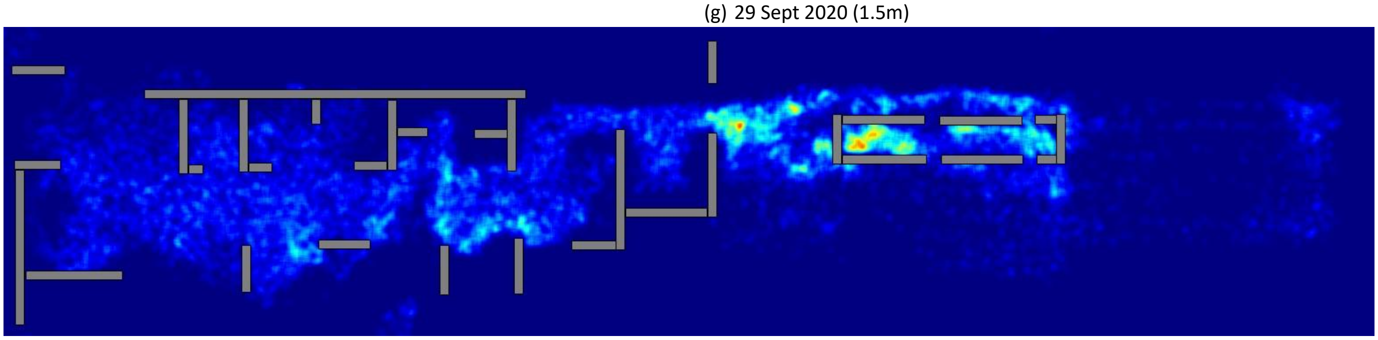
FIGURE 11(B)(D)(F)



(f) 28 Sept 2020 (1.5m)



(g) 29 Sept 2020 (1.5m)



(h) 30 Sept 2020 (1.5m) Visualization of

most distance offences in the Kromhouthal.