MediaEval 2014 Visual Privacy Task: Context-Aware Visual Privacy Protection

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ABSTRACT
In this paper, we describe a privacy filter proposed for VPT 2014 in an attempt to provide a context-aware solution. The proposed solution comprises three different techniques applied to the face, skin, and body regions separately. The proposed combination of filtering techniques aimed to produce an adaptive solution and provide an example of a context-aware-like privacy filtering capability. The results demonstrated the effectiveness of the proposed techniques in maintaining a high level of *Intelligibility* and retaining the appeal of the video i.e. *Pleasantness*. However the still identifiable gender and race of certain individuals contributed to the perception of lower levels of privacy of the person in the case of some of the video frames.

Categories and Subject Descriptors
I.2.10 [**Artificial Intelligence**]: Vision and Scene Understanding - v*ideo analysis, representations, data structure, and transforms*

1. INTRODUCTION
The Visual Privacy Task at MediaEval 2014 [1] acknowledged that the perceived privacy of a citizen cannot be divorced from the contexts in which the privacy is valued by the citizen and thus worth protecting. A citizen may have a variety of roles, responsibilities and relationships; each associated with a particular persona which may be activated in a given context within their everyday life-style e.g. husband, father, employee, boss etc. Each such persona of the citizen is commensurate with a particular privacy boundary linked to a certain context. This could guide the levels and scopes of privacy filtering according to the situated (context-dependent) scenario. The VPT task evaluation methodology has responded to the need for a more inclusive, holistic and high resolution assessment of privacy filtering requirements as well as the evaluation of the efficacy and impacts of the resulting privacy filtering solutions based on the UI-REF methodology [2]. The PEViD dataset [3] was updated with privacy ranking system for the subject body parts for context-aware impact assessment of privacy protection solutions.

2. THE PROPOSED FILTER
We proposed a privacy filter which primarily aims to achieve a balance in the well-addressed *Privacy-Intelligibility* trade-off. In addition, the *Pleasantness* and the appropriate filter application criteria are also considered alongside the real-time applicability. Accordingly our three different filtering techniques for face, skin, and body regions of the subject featured in the video were applied as follows:

MediaEval 2014 Workshop, October16-17, 2014, Barcelona, Spain

Figure 1: Outputs of the proposed filter

Face filter (H): The face being a highly identity revealing region has been ranked high (H) for privacy protection compared to other body parts. Accordingly, we sought to ensure the anonymity of the visible face. First an empirical threshold was set to examine the minimum size of the face in which it could be identifiable (i.e. 50 pixels in our case, rightmost snapshot in Figure 1). Below the said threshold, a simple median blur filter proved sufficient to protect the person's identity. Once the face size exceeded the threshold, a key point detector was applied on the face region followed by adaptive colour quantisation and circle texturing to produce the effect as shown in Figure 1.

Skin filter (M): The exposed skin regions could provide sufficient information to enable the detection of the ethnicity of the subject. Skin provides a focus of attention. Exposed skin regions, e.g. hands, are also important in activity recognition and detection of weapons. Therefore, morphologic changes or non-homogenous colour changes are not suitable in this case. To manipulate the skin region in a unified fashion, we reduced the colour saturation and luminance values in the R, G, and B colour channels separately within the oriented boxes enclosing the skin regions. The filtered skin regions were still recognisable. There are only two identifiable skin colours: light-like and dark-like. The skin texture which is responsible for the skin attractiveness was also eliminated.

Person filter (L): The last stage of privacy protection is applied to the bounding box enclosing the subject region. This region is ranked low in the provided annotation. An edge-based analysis is implemented on the foreground region(s) within the subject bounding box. The procedure begins with morphological operations to enhance the foreground mask to reduce the background noise and minimise the holes in the foreground region. Canny edge detector is subsequently applied and further refined to eventually draw the subject's contour. The final effect produced as depicted in Figure 1 is the result of a distance transformation which calculates the distance of each pixel of the

resulting binary contour map with the closest zero pixel in the image. OpenCV implementation based on [4] was used which calculate the Euclidean distance to the nearest zero pixel consisting of basic shifts: horizontal, vertical, diagonal, or knight's move. A mask of size (5 X 5) was used for the best results.

3. EVALUATION RESULTS

A subjective evaluation consist of three (3) streams were conducted and the performance of the proposed privacy protection solution is examined in terms of the defined criteria namely, *Privacy*, *Intelligibility*, and *Pleasantness* as described in [1].

Figure 2-5 illustrate the performance of the proposed solution in the three evaluation streams respectively. A noticeable trend can be generalised from the three sets of results with only marginal variations.

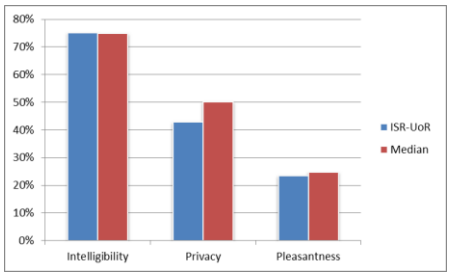

Figure 2: Scores from Stream 1

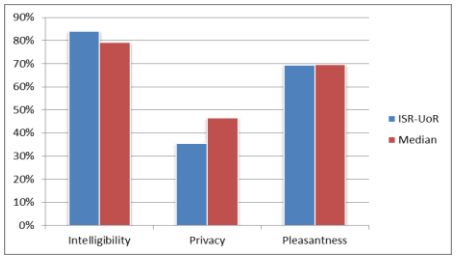

Figure 3: Scores from Stream 2

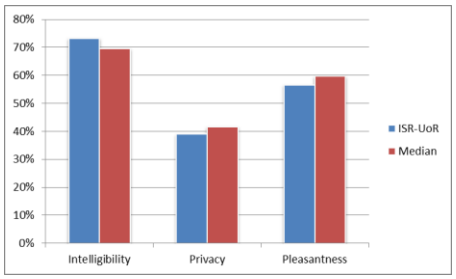

Figure 4: Scores from Stream 3

The proposed solution scored above the average for *Intelligibility* criterion and well above the region of 70% in the three streams which ensures that the processed video will still serve the main purpose of CCTV security objective.

However, the *Privacy* scores were slightly below the median which is in general below the value of 50% in this competition. One possible explanation of the overall low score of *Privacy* is the fact that this criterion has been measured based on the ability to identify the gender and the ethnicity of the person which could be hard to conceal without significantly manipulating the person appearance. On the other hand, the proposed solution would clearly prevent the viewer from being able to identify the featured subject in the normal cases by successfully hide most of the face details. Regarding the *Pleasantness* criterion the obtained scores were comparable to the median values for the three streams which fell within the range of 50-70% for stream 2 and 3 and noticeably lower for stream 1 for slightly above 20%. Table 1 summarises the numerical values of the obtained scores for the evaluated streams.

	Intelligibility	***Privacy***	***Pleasantness***
Stream_1	75.10%	42.80%	23.50%
Stream_2	84.07%	35.55%	69.27%
Stream_3	73.27%	39.01%	56.61%

Table 1: Scores for evaluated streams

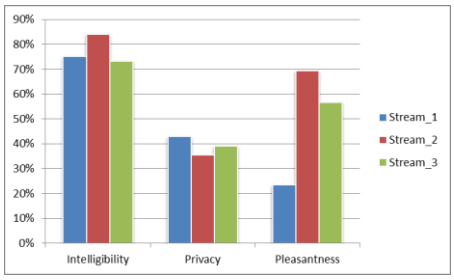

Figure 5: Integrating the scores for all three streams

4. CONCLUSION

In this paper we have proposed a video privacy filter using a combination of filtering techniques to simulate a context-aware solution. The filter aims to achieve the highest privacy with minimum content distortion and viewer distraction. The obtained scores were comparable to the average values of the scores for all the privacy filtering solutions as proposed for the Visual Privacy Task 2014. One possible future work would be the addition of person re-identification test to be included in evaluating the *Privacy* criterion as an important aspect.

5. ACKNOWLEDGMENTS

We would like to thank Lucas Teixeira and Kevin Lelu for their valuable inputs. This work was supported by the European Commission under contracts FP7-261743 VideoSense project.

6. REFERENCES

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