Behaviour modelling and life logging

Research topic no. 10:

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Presentation agenda

- Introduction to the topic
- Motivation
- Available work
- Open problems
- Methodology
- Publications
- Presentation summary

Introduction to the topic

- ✓ Life logging - a technology that uses wearable sensors to gather, store, and process data from the daily lives of an individual.
- ✓ Using a wearable camera can illustrate in detail which activities the person wearing the camera has done.
- ✓ This thesis aims to create computer vision lifelogging systems for health improvement.

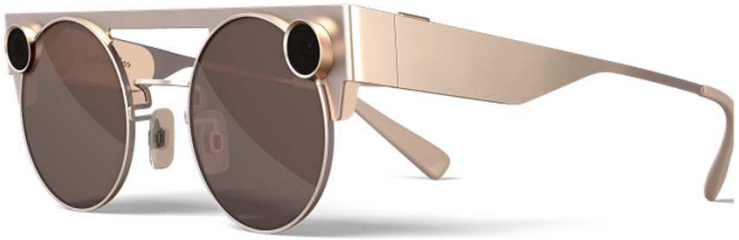
User wearing a lifelogging device[1]

[1] https://newatlas.com/narrative-clip-2/35422/

Devices for egocentric video life logging

Narrative Clip[2]

RayBan Stories[3]



Spectacles 3[4]

GoPro Hero[5]

[2] http://getnarrative.com
[3] https://www.ray-ban.com/canada/en/electronics/ray-ban%20stories%20%7C%20round-shiny%20black/8056597705035
[4] https://www.spectacles.com/at/shop/spectacles-3/
[5] https://gopro.com/de/at/shop/cameras/hero9-black/CHDHX-901-master.html

Motivation behind the project

- ✓ The aging population demands new technological solutions to reduce the involved medical personnel.
- ✓ The technological progress and miniaturization of electronic devices and sensors provide new systems for life logging, including cameras.
- ✓ Available work is focused in general on processing egocentric image streams or videos.
- ✓ This work will study the possibilities of egocentric visual data processing for health and lifestyle improvement.

Fields of egocentric images applications

- ✓ Temporal segmentation
- ✓ Action Recognition
- ✓ Routine discovery
- ✓ Food scenes classification
- ✓ Social interaction characterization

Temporal segmentation

Explanation

- ✓ Egocentric video and photo streams are large unstructured data.
- ✓ Dividing photo stream into moments/scenes.
- ✓ Information about Activities of Daily Living(ADL).

Examples:

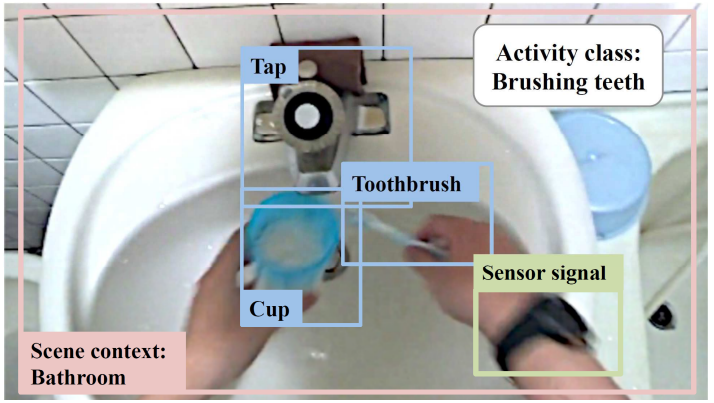
- ✓ Classifiers based on low-level features image representation[7].
- ✓ A combination of CNN and color histogram features to predict what a camera wearer does[6]
- ✓ Unsupervised clustering method based on agglomerative clustering[8]

[6] D. Castro, S. Hickson, V. Bettadapura, E. Thomaz, G. Abowd, H. Christensen, I. Essa, Predicting daily activities from egocentric images using deep learning, proceedings of the 2015 ACM International symposium 700 on Wearable Computers (2015)
[7] A. R. Doherty, A. F. Smeaton, Automatically segmenting lifelog data into events, Proceedings of the Ninth International Workshop on Image Analysis for Multimedia Interactive Services (2008) 20–23.
[8] E. Talavera, M. Dimiccoli, M. Bola˜nos, M. Aghaei, P. Radeva, R-clustering for egocentric video segmentation, Lecture Notes in Computer Science 9117 (2015) 327–336.

Action recognition

Explanation

- ✓ Task of discovering action happening in the image.
- ✓ Object-based, motion-based, hybrid approaches.
- ✓ Detection of actions during the day allows describing the user's activity.



Example of a detected activitiy basing on objects[9]

Examples:

- ✓ Action recognition performance improvement by modeling the visual tempo of actions that characterize the dynamics and the temporal scale of action[10].

[9] P.-J. Hsieh, Y.-L. Lin, Y.-H. Chen, and W. Hsu, "Egocentric activity recognition by leveraging multiple mid-level representations," in 2016 IEEE International Conference on Multimedia and Expo (ICME), pp. 1–6, IEEE, 2016.
[10] C. Yang, Y. Xu, J. Shi, B. Dai, and B. Zhou, "Temporal pyramid network for action recognition," in Proceedings of the IEEE/CVF Conference on Computer Vision and Pattern Recognition, pp. 591–600, 2020.

Routine discovery

Explanation

- ✓ Automated solution for routine discoveries of a camera wearer.
- ✓ Routines are sequences of actions that are happening regularly or at specific intervals.
- ✓ Several studies based on GPS modules with satisfactory results

Examples:

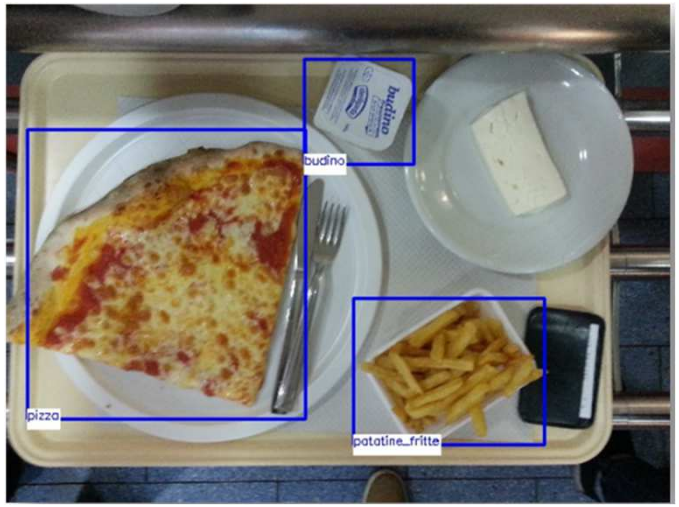
- ✓ Egocentric visual routines discovery into routine vs non-routine days[11].
- ✓ Employing GPS data sequences to cluster days with similar routines[12].

[11] E. Talavera, N. Petkov, P. Radeva, Unsupervised routine discovery in egocentric photo-streams, 18th Conference on Computer Analysis of Images and Patterns (2019).
[12] J. Biagioni, J. Krumm, Days of our lives: assessing day similarity from location traces, in: International Conference on User Modeling, Adaptation, and Personalization, Springer, 2013, pp. 89–101.

Food scene monitoring

Explanation:

- ✓ Detection and processing of scenes containing meals and food.
- ✓ The part of a healthy diet is food that is being eaten, ethics regarding the time on consumption and schedule, and places of food intake.
- ✓ By analyzing the environment where the camera wearers spend time, their behavior, habits, and even health can be described, studied, and improved.



Example of a food recognition[13]

Examples:

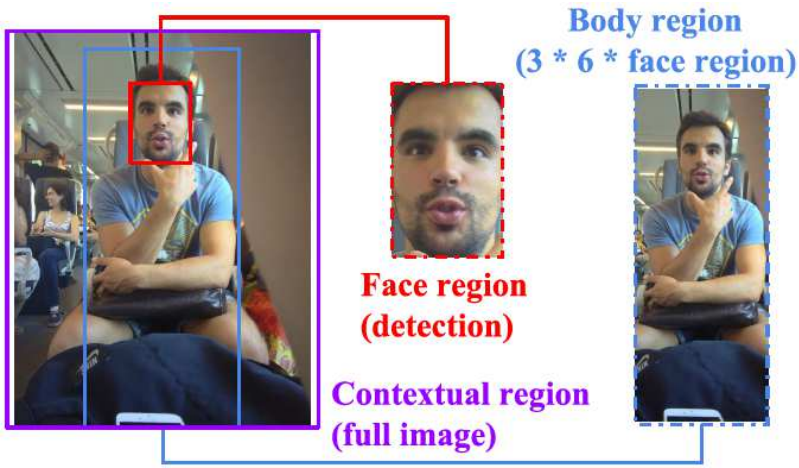
- ✓ Food Scenes classification with DL for food place classification[14].
- ✓ Hierarchical classification of food related scenes[15]
- ✓ Detecting food in egocentric images[16]

[13] E. Aguilar, B. Remeseiro, M. Bola˜nos, and P. Radeva, "Grab, pay, and eat: Semantic food detection for smart restaurants," IEEE Transactions on Multimedia, vol. 20, no. 12, pp. 3266–3275, 2018.
[14] M. K. Sarker, H. A. Rashwan, E. Talavera, S. Furruka Banu, P. Radeva, D. Puig, et al., Macnet: Multi-scale atrous convolution networks for food places classification in egocentric photo-streams, in: Proceedings of the European Conference on Computer Vision (ECCV).
[15] E. Talavera, M. Leyva-Vallina, M. Sarker, D. Puig, N. Petkov, P. Radeva, Hierarchical approach to classify food scenes in egocentric photo-streams, Journal of Biomedical and Health Informatics (2019).
[16]Wenyan Jia, Yuecheng Li, Ruowei Qu, Thomas Baranowski, Lora E Burke, Hong Zhang, Yicheng Bai, Juliet M Mancino, Guizhi Xu, Zhi-Hong Mao, et al. Automatic food detection in egocentric images using artificial intelligence technology. Public health nutrition, 22(7):1168–1179, 2019.

Social interaction characterization

Explanation:

- ✓ Automated analysis of egocentric images for the social interaction pattern descriptions.
- ✓ The faces of people from the captured scene are the primary source of information.
- ✓ Lack of social relations leads to health problems like inflammation, adolescence, hypertension, and decreasing psychological wellbeing[17].



The example of face, body and contextual regions extraction[21]

Examples:

- ✓ Multi-face tracking for first person captured photo streams[18].
- ✓ Classifications of social interactions into formal and informal type[19].
- ✓ Social characteristic of a person based on numerical statistics from interactions[20].

[17] Estefania Talavera, Nicolai Petkov, and Petia Radeva. Egocentric vision for lifestyle understanding. In Wearable Sensors, pages 415–433. Elsevier, 2021
[18] M. Aghaei, M. Dimiccoli, P. Radeva, All the people around me: face discovery in egocentric photo-streams, in: IEEE International Conference on Image Processing (ICIP), pp. 1342–1346.
[19] M. Aghaei, M. Dimiccoli, C. C. Ferrer, P. Radeva, Towards social pattern characterization in egocentric photo-streams, Computer Vision and Image Understanding 171(2018)104-117.
[20] E. Talavera, A. Cola, N. Petkov, P. Radeva, Towards egocentric person re-identification and social pattern analysis, 1st Applications of Intelligent Systems (APPIS) (2018).
[21] Emanuel Sanchez Aimar, Petia Radeva, and Mariella Dimiccoli. Social relation recognition in egocentric photostreams. In 2019 IEEE International Conference on Image Processing (ICIP), pages 3227–3231. IEEE, 2019.

Open problems

- ✓ What specific actions factoring subjects' health can be tracked throughout the day to improve their lifestyle and well-being?
  - ✓ Can we accurately model negative behaviors?
- ✓ Majority of works focuses on the food scenes. Is it possible to apply egocentric image life logs to determine the fluid intake habits of subjects?
  - ✓ Can we track the amount of taken fluids?
  - ✓ Can we track what kind of fluids is taken?
- ✓ What social signals can we detect in social events between people wearing a camera to improve their health?
  - ✓ What psychological diseases can we indicate in such data?
  - ✓ How can we employ facial and posture analysis?

Next steps

- ✓ Defining negative and positive behaviors for monitoring purposes
  - ✓ Hierarchical sorting of them in terms of difficulty level
  - ✓ Implementation plan including data planning
- ✓ Defining trackable social signals:
  - ✓ Data preparation
  - ✓ Creation of automatic system
  - ✓ Evaluation of the system
- ✓ Plan of fluid intake system:
  - ✓ Implementation plan
  - ✓ Data preparation with additional creation
  - ✓ Implementation and tests

Methodology

- ✓ Computer Vision techniques
  - ✓ Deep Learning models and AI
- ✓ Own data creation
- ✓ Employment of available datasets
- ✓ Interdisciplinary research and collaboration

Table of available datasets in egocentric vision.

Dataset name	Purpose	Type
EgoSocialStyle	Social	Images
EGO-GROUP	Social	Video
EgoRoutine	Routine	Images
EDUB-Obj	Segmentation, Obj. Detc.	Images
EGO4D	Social	Video
LBSoEV	Location	Video
OEVDLA	Action Recognition	Video
Home Action Genome	Action Recognition	Video
EDUB-Seg	Segmentation	Images
DoMSEV	Action Recognition	Video
GTEA	Action Recognition	Video

Publications

- **Depth and Thermal Images in Face Detection - A Detailed Comparison Between Image Modalities**

✓ Accepted: The 5th International Conference on Machine Vision and Applications

(ICMVA 2022), February 18-20 2022, Singapore,

- **Beyond Privacy of Depth Sensors in Active and Assisted Living Devices**

✓ Accepted**:** PETRA 2022 - Beyond Privacy of Depth Sensors in Active and Assisted Living Devices, Corfu, Greece

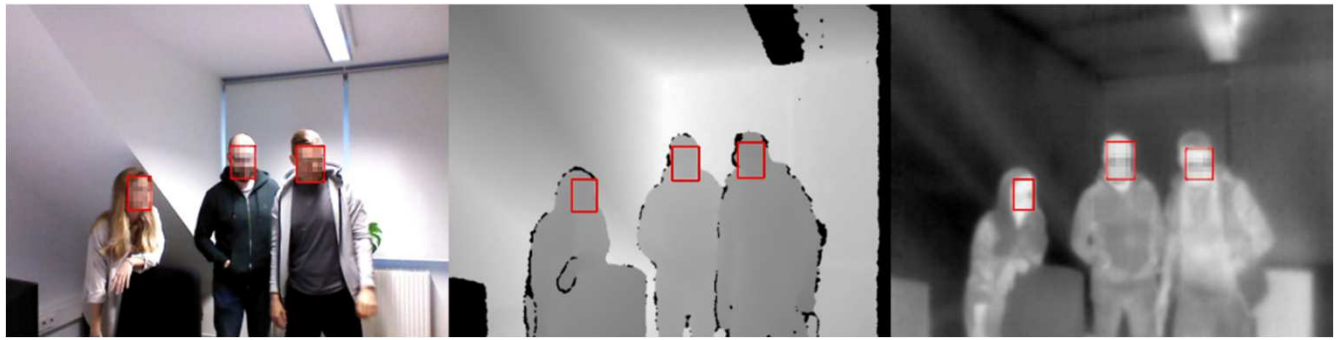
- **Addressing Privacy Concerns in Depth Sensors**

✓ Accepted**:** Joint International Conference on Digital Inclusion,

Assistive Technology & Accessibility - ICCHP-AAATE 2022, Lecco, Italy

Depth and Thermal Images in Face Detection - A Detailed Comparison Between Image Modalities

- ✓ Implementation of Face Detection (FD) model for three different image modalities (depth, thermal, RGB).
- ✓ Creating annotations for faces in existing datasets.
- ✓ A trimodal dataset for FD task - Contains perfectly aligned images of the same scene in depth, thermal and RGB.
- ✓ A detailed comparison of three image modalities in the example of FD task.

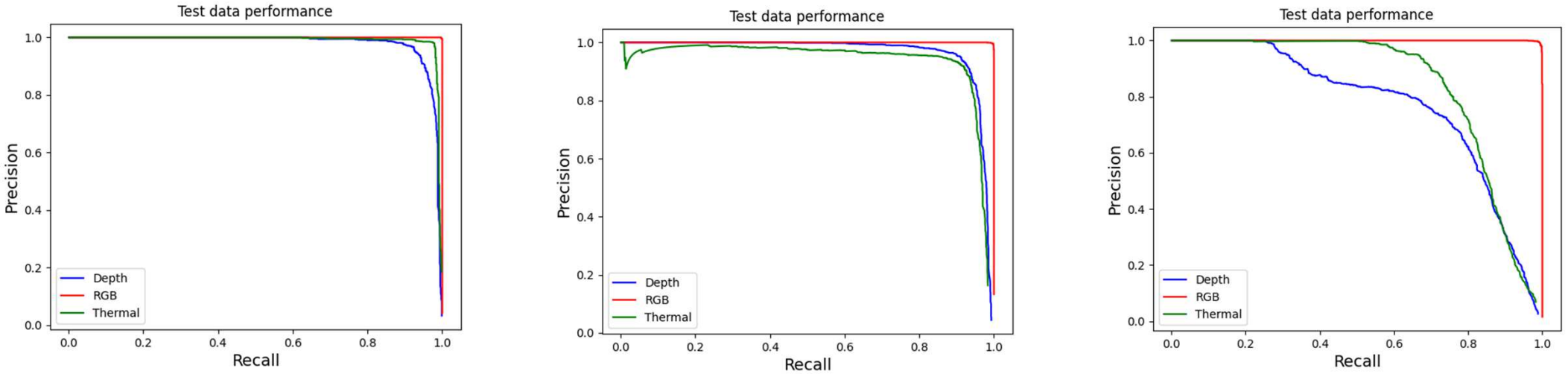


Example of a correct detection on each image modality, form left RGB, depth and thermal image

Depth and Thermal Images in Face Detection - A Detailed Comparison Between Image Modalities

Conclusions:

- ✓ FD is often a part of a pipeline in Active and Assisted Living (AAL) devices.
- ✓ Depth and thermal models are robust enough to be used in practice.
- ✓ The non-RGB models fail in the hardest conditions, where multiple faces are present in the scene, often occluded and in a distance from the camera.
- ✓ The RGB sensor is not always necessary.



Precision-recall curves for easy, medium and hard test scenarios

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Addressing Privacy Concerns in Depth Sensors

- ✓ AAL vision-based systems raise privacy concerns due to monitoring patients
- ✓ Other types of images than RGB are used to maintain privacy. There are contradictory statements about privacy of depth cameras.
- ✓ The factors affecting privacy in depth images.
- ✓ Comparison of Face Recognition (FR) technique between RGB and depth images.

Same scene visible in deptn and RGB image.

Addressing Privacy Concerns in Depth Sensors

Conclusion:

- ✓ FR in depth is based on similar face features like in RGB image.
- ✓ A comparison favored RGB over depth with a significant accuracy difference.
- ✓ The high accuracy in depth FR was achieved in datasets with a low number of subjects.
- ✓ DL methods showed improvement in the accuracy of FR, even on small face resolutions.
- ✓ These circumstances make depth data more private than RGB, but when designing depth-based monitoring solutions, it is necessary to consider the possible disclosure of subjects' identities.

Face presented in depth and RGB modality

Presentation summary

- ✓ Life logging in computer vision and its benefits
- ✓ Fields of applying egocentric vision
- ✓ Open questiones and problems
- ✓ Future steps
- ✓ Carried out publications

Thank you!

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