Media Operations Use Case for an Augmented Reality Application on Edge Computing Infrastructure

https://tools.ietf.org/html/draft-krishna-mops-ar-use-case-02

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New Sub-sections

Updates

- We clarify that it is the heat and battery drainage problems in AR devices that require offloading of computationally intensive tasks to the edge.
- We list the kind of computationally intensive tasks that are required and give references for further details.

Offloading Computationally intensive tasks

- The components of AR applications perform tasks such as real-time generation and processing of high-quality video content that are computationally intensive.
  - As a result, on AR devices such as AR glasses excessive heat is generated by the chip-sets that are involved in the computation [DEV_HEAT_1], [DEV_HEAT_2].
  - Additionally, the battery on such devices discharges quickly when running such applications [BATT_DRAIN].

Computationally intensive task: Processing of scenes

- The AR application that runs on the mobile device needs to first track the pose (coordinates and orientation) of the user's head, eyes and the objects that are in view.
  - This requires tracking natural features and developing an annotated point cloud-based model that is then stored in a database.
  - To ensure that this database can be scaled-up, techniques such as combining a client-side simultaneous tracking and mapping and a server-side localization are used [SLAM_1], [SLAM_2], [SLAM_3], [SLAM_4].
- Once the natural features are tracked, virtual objects are geometrically aligned with those features.
- This is followed by resolving occlusion that can occur between virtual and the real objects [OCCL_1], [OCCL_2].
- The next step for the AR application is to apply photometric registration [PHOTO_REG]. This requires aligning the brightness and color between the virtual and real objects.
- Additionally, algorithms that calculate global illumination of both the virtual and real objects [GLB_ILLUM_1], [GLB_ILLUM_2] are executed.
- Various algorithms to deal with artifacts generated by lens distortion [LENS_DIST], blur [BLUR], noise [NOISE] etc are also required.

Computationally intensive task: Generation of images

- The AR application must generate a high-quality video that has the properties described in the previous step and overlay the video on the AR device's display- a step called situated visualization.
  - This entails dealing with registration errors that may arise,
  - Ensuring that there is no visual interference [VIS_INTERFERE],
  - Finally maintaining temporal coherence by adapting to the movement of user’s eyes and head.

Next Steps

- Questions, Comments and Suggestions are invited to improve the draft.
- Adoption by the WG?

Informative references- 1

[DEV_HEAT_1] LiKamWa, R., Wang, Z., Carroll, A., Lin, F., and L. Zhong, "Draining our Glass: An Energy and Heat characterization of Google Glass", In Proceedings of 5th Asia-Pacific Workshop on Systems pp. 1-7, 2013.

[DEV_HEAT_2] Matsuhashi, K., Kanamoto, T., and A. Kurokawa, "Thermal model and countermeasures for future smart glasses.",In Sensors, 20(5), p.1446., 2020.

[BATT_DRAIN] Seneviratne, S., Hu, Y., Nguyen, T., Lan, G., Khalifa, S., Thilakarathna, K., Hassan, M., and A. Seneviratne, "A survey of wearable devices and challenges.", In IEEE Communication Surveys and Tutorials, 19(4), p.2573-2620., 2017.

[SLAM_1] Ventura, J., Arth, C., Reitmayr, G., and D. Schmalstieg,"A minimal solution to the generalized pose-and-scale problem", In Proceedings of the IEEE Conference on Computer Vision and Pattern Recognition, pp. 422-429, 2014.

[SLAM_2] Sweeny, C., Fragoso, V., Hollerer, T., and M. Turk, "A scalable solution to the generalized pose and scale problem", In European Conference on Computer Vision, pp. 16-31, 2014.

[SLAM_3] Gauglitz, S., Sweeny, C., Ventura, J., Turk, M., and T. Hollerer, "Model estimation and selection towards unconstrained real-time tracking and mapping", In IEEE transactions on visualization and computer graphics, 20(6), pp. 825-838, 2013.

[SLAM_4] Pirchheim, C., Schmalstieg, D., and G. Reitmayr, "Handling pure camera rotation in keyframe-based SLAM", In 2013 IEEE international symposium on mixed and augmented reality (ISMAR), pp. 229-238, 2013.

Informative references-2

[OCCL_1] Breen, D., Whitaker, R., and M. Tuceryan, "Interactive Occlusion and automatic object placement for augmented reality", In Computer Graphics Forum, vol. 15, no. 3 , pp. 229-238,Edinburgh, UK: Blackwell Science Ltd, 1996.

[OCCL_2] Zheng, F., Schmalstieg, D., and G. Welch, "Pixel-wise closed-loop registration in video-based augmented reality", In IEEE International Symposium on Mixed and Augmented Reality (ISMAR), pp. 135-143, 2014.

[PHOTO_REG] Liu, Y. and X. Granier, "Online tracking of outdoor lighting variations for augmented reality with moving cameras", In IEEE Transactions on visualization and computer graphics, 18(4), pp.573-580, 2012.

[GLB_ILLUM_1] Kan, P. and H. Kaufmann, "Differential irradiance caching for fast high-quality light transport between virtual and real worlds.", In IEEE International Symposium on Mixed and Augmented Reality (ISMAR),pp. 133-141, 2013.

[GLB_ILLUM_2] Franke, T., "Delta voxel cone tracing.", In IEEE International Symposium on Mixed and Augmented Reality (ISMAR), pp. 39-44, 2014.

[LENS_DIST] Fuhrmann, A. and D. Schmalstieg, "Practical calibration procedures for augmented reality.", In Virtual Environments 2000, pp. 3-12. Springer, Vienna, 2000.

[BLUR] Kan, P. and H. Kaufmann, "Physically-Based Depth of Field in Augmented Reality.", In Eurographics (Short Papers), pp. 89-92., 2012.

Informative references-3

[NOISE] Fischer, J., Bartz, D., and W. Strasser, "Enhanced visual realism by incorporating camera image effects.", In IEEE/ACM International Symposium on Mixed and Augmented Reality, pp. 205-208., 2006.

[VIS_INTERFERE] Kalkofen, D., Mendez, E., and D. Schmalstieg, "Interactive focus and context visualization for augmented reality.", In 6th IEEE and ACM International Symposium on Mixed and Augmented Reality, pp. 191-201., 2007.