E3.4: White paper on recommendation systems for developers and users based on energy consumption of apps.

The recommendation system was implemented to provide personalized suggestions or recommendations to users. Here, the focus was based on image selection-based recommender system. Our focus lies on addressing the energy consumption associated with images, which are one of the primary components consuming energy in Android applications. The goal was to propose a recommender system that can select images with lower energy consumption, marking a novel approach in this field. Calculating the energy consumption of image operations in a typical scenario is challenging as there are no direct methods available. Hence, one of the key obstacles in energy consumption calculation is determining the appropriate approach. To address this, we introduce a method based on Android Profiler and explore the correlation between energy consumption, image quality, and image file size. Consequently, image quality and file size can be considered as proxies for energy consumption.

The proposed recommender system is based on a multi-objective strategy in JPEG image compression, to reduce energy consumption so that the quality of the image is improved and the size of the file is also reduced. To this end, we have employed two general multi-objective metaheuristic approaches: scalarisation and Pareto-based. Scalarisation methods find a single optimal solution based on combining different objectives, while Pareto-based techniques aim to achieve a set of solutions. In this task, we embed our strategy into five scalarisation algorithms and two Paret-based approaches.

While the above-mentioned recommender system can work well, it does not take into consideration the user's opinion. Take an android developer as an example, who prefers a small-size image, while the optimisation process results in a high-quality image, leading to a huge file size. Therefore, we improved the recommender system so that it includes the user's opinion. Since the new variant is based on the objective function and the representation, it is independent of the search strategy. Therefore, we also apply 22 search strategies to our new formulation to find the optimal recommender system with higher accuracy.

Results of our two general recommendation systems based on different algorithms and different benchmarks can suggest a recommender system to a developer to select an image with optimised energy consumption.

In summary, the main contributions for this part are as follows.

1. We conducted an in-depth exploration of the intricate correlation between energy consumption and image properties, such as quality and file size.
2. We introduced a pioneering multi-objective strategy to empower developers with a recommender system for selecting images with optimized energy consumption.
3. This recommender system was seamlessly integrated into five scalarization methods and two established Pareto-based approaches.

4. To address user-specific requirements, we incorporated a user-specified file size constraint, ensuring that the user's preferences are accommodated in the image selection process.
5. Our improved recommender system was subjected to rigorous testing across 22 different algorithms, elevating its capability to identify the optimal solution.

These findings have been documented in the following publications:

- Seyed Jalaleddin Mousavirad, and Luis A. Alexandre, Energy-Aware JPEG Image Compression: A Multi-Objective Approach, Applied Soft Computing, Vol. 141, 2023
- Seyed Jalaleddin Mousavirad, and Luis A. Alexandre, Metaheuristic-based Energy-aware Image Compression for Mobile App Development, Submitted to the related journal, ArXiv link: https://arxiv.org/abs/2212.06313