8. Conclusions

The presented thesis introduces several novel methods that leverage state-of-the-art machine learning algorithms to develop recommendation systems. Given the subjective nature of evaluating system performance, rather than solely maximizing accuracy measures as outlined in subsection 1.2.1, our primary focus was on enhancing the interpretability of the obtained recommendations. The proposed algorithms have been designed to effectively handle various types of data commonly encountered in recommendation systems and have demonstrated their efficacy.

Firstly, extensive research was conducted to develop a recommendation system that accurately maps the user's profile while maintaining the generalization of knowledge within the neural network. The proposed recommendation system is built upon deep learning techniques and achieves high efficiency through the application of a hybrid structure that combines neural networks for both nominal and non-nominal attributes. Additionally, this system incorporates a module that provides interpretability for the recommended objects. This means that each selected proposal in the ranking list is accompanied by an explanation of why it was recommended to the user. To investigate the interpretability of the recommendation system, a simulation was performed using the MovieLens 20M dataset. In our proposed method, a hybrid approach is crucial. By utilizing a model based on Collaborative Filtering, recommendations could be calculated at the general population level, effectively mitigating the negative impact of the cold-start phenomenon, which often affects newly registered users. Furthermore, we developed an additional structure to operate based on the Content-Based filtering methodology. This approach enabled the creation of individual models for users aiming to track the relationship between attribute values of selected items and the user's ratings within the system. Both recommendation modules were assembled using a proprietary algorithm, which determines the final recommendation result.

Furthermore, the use of the t-SNE algorithm for visualization purposes was proposed. This algorithm facilitated dimension reduction, representing each item in a three-dimensional space. Consequently, each point in this 3D space corresponds to a specific item, and the distance between two points reflects the similarity of their characteristics. By arranging the user's decision-making space in three dimensions, we were able to identify distinct groups of films that significantly align with the user's preferences. This visualization technique serves as valuable support for the results generated by the recommendation system. By calculating a high recommendation value, we can assess the likelihood of a particular item appealing to the user's taste based on its position in the visualized space. This provides a means to validate the system's recommendations and further ensures that the recommended films are aligned with the user's preferences.

In a second proposed approach, a recommendation system leveraging the Bahdanau attention mechanisms, originally employed in speech processing, was designed. In this system, the attention mechanism was employed to highlight the most relevant regions of an image. The system also includes the capability to describe photos in terms of classes, which are the output of a classifier connected to the CNN network. Simulations were conducted using the Zappos50K database. Extensive research on the crucial image features culminated in the development of an AI model based on the attention generated by the encoder-decoder structure for the images. This model is utilized for classification based on the attentions obtained for the images. Consequently, the classifier highlights the most significant areas of the images, enabling the emphasis of the distinctive characteristics of each class.

Furthermore, limitations in the Occlusion Sensitivity method, particularly the constraint of a fixed window size was identified. This constraint not only impacts the calculation speed but also affects the overall results displayed in the heat map. To address this limitation, we propose an algorithm based on a recursive search for images, leveraging the results obtained from the softmax function. This algorithm enables the generation of attention areas of different sizes, which is lacking in the original Occlusion Sensitivity method. Moreover, the algorithm is optimized for efficient parallel computing performance. To evaluate the proposed modification of the Occlusion Sensitivity method, simulations were conducted using the MS COCO 2017 database. The EfficientNetB7 model, pre-trained on the mentioned database, was utilized for this purpose. Due to the nature of the multi-label operation, the network generates recognition in the form of multiple classes assigned to a single object. This structure proves highly effective when applied to instance segmentation, generating bounding boxes for each instance in the image. For each detected bounding box, the proposed algorithm was applied. The content within the bounding box was masked to isolate it from the rest of the image. Subsequently, the modified Occlusion Sensitivity algorithm was employed. This process generated a set of attentions for each image, allowing the capture of the most characteristic areas within it. The proposed method, by offering the ability to generate attentions of varying sizes, enables more precise examination of the network's output and, consequently, facilitates more accurate supervision over the network training process.

Finally, limitations in the GradCAM method, specifically regarding the calculation of the guided gradient, which only considers positive gradients propagated by the network during the error backpropagation algorithm were addressed. To mitigate this limitation, we propose an approach that incorporates analysis of non-zero gradients, including both positive and negative values. By modifying the GradCAM algorithm in this manner, we can interpret the neural network's operation by examining the gradients calculated from the backpropagation process. The utilization of this modified GradCAM method in recommendation systems allows for the visualization of the neural network's operation. This visualization capability provides support for decision-making processes, particularly in domains like medicine. For instance, we propose a system for classifying patient X-rays based on diagnostic recommendations for COVID-19. It becomes crucial to train the neural network in subsequent iterations, leveraging the insights gained from the heat maps generated by the modified GradCAM algorithm. This iterative process aids in refining the network's performance and improving its ability to accurately classify X-rays and provide diagnostic recommendations.

The conducted analyses and the proposed methods presented in this dissertation are valuable contributions to the current understanding of recommendation systems. However, it is important to acknowledge that the dynamic nature of machine learning methods requires ongoing work to adapt them effectively to the implementation of recommendation tasks. Further efforts are needed to enhance the interpretability of the received recommendations. Nonetheless, the algorithms discussed in this dissertation provide significant advancements and insights in the field, serving as a solid foundation for future research and development in recommendation systems.