Systematizing Filtering Activities in Information Visualization and Visual Analytics: A Literature Review

Supplemental Materials

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Contents

1 Introduction

This additional material was created to report all the results of the analyzes carried out for each individual taxonomic group and is an essential component of the scientific article on filtering in information visualization and visual analytic systems. Its creation was motivated by the need to enrich and consolidate the research presented in the article itself. This material was specifically developed with the aim of offering a detailed and in-depth analysis of the significant differences that emerged during the study of the various taxonomic groups examined. In doing so, it contributes substantially to ensuring the transparency, completeness and reproducibility of the scientific research that has been conducted. Transparency is fundamental because it allows other scholars to critically evaluate the methodology used and the data collected, allowing them to verify and validate the results presented in the article. This aspect is crucial for the credibility of scientific research and for promoting progress in the field of the study of visual systems. Furthermore, the complete exposure of the analysis results for each taxonomic group allows other researchers to further deepen their work by conducting further research based on this detailed information. This can contribute to further discoveries and developments in filtering in visual systems, thus enhancing the scientific knowledge base available to the scientific community and interested public.

2 Analysis of the inverse proportionality of filters with respect to direct manipulation (A1)

The study links the amount of filters and direct manipulations and is critical for understanding how these two variables are connected and how they might impact each other inside visual systems.

For this analysis it was initially hypothesized that as the number of filters increased there would be a decrease in the number of direct manipulations, suggesting that the introduction of more filters could partially replace the need for direct manipulations by users. However, the results obtained from the initial analysis contradicted this hypothesis, showing a flat trend between the number of filters and the number of direct manipulations. This means that, in general, the increase in filters has not significantly affected the amount of direct

manipulations used in visual analytics systems.

However, subsequently rerunning the analysis for each taxonomic group, a more detailed picture of the relationship between filters and direct manipulations emerged. It became evident that although the overall analysis may show a flat trend, when analyzing the data more granularly, different trends can be detected. Many of these sub-analyses have shown that, in reality, there is a directly proportional relationship between the number of filters implemented and the number of direct manipulations. In other words, as the number of filters increases, the number of direct manipulation interactions by users also increases.

These findings highlight the importance of examining data in detail and not relying only on aggregate results, and suggest that introducing more filters may not necessarily replace direct manipulations, but rather may encourage more complex interactions between the user and the visual analysis system.

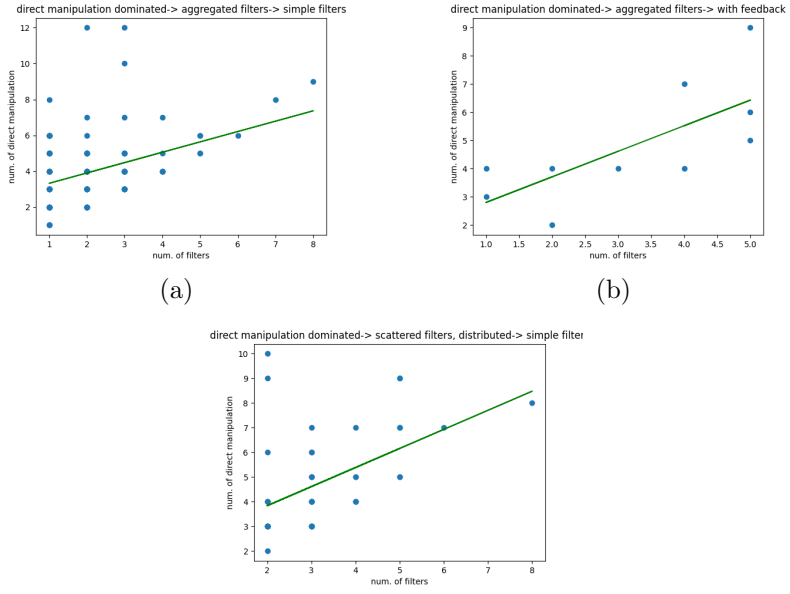


Figure 1: A1 analysis by taxonomic groups.

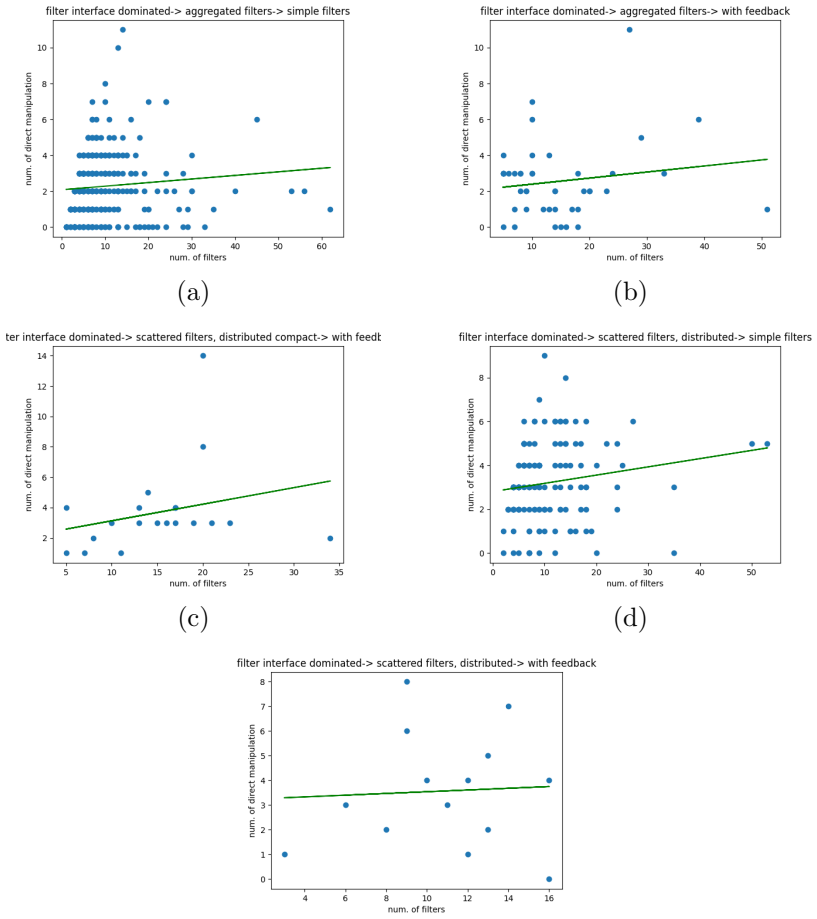


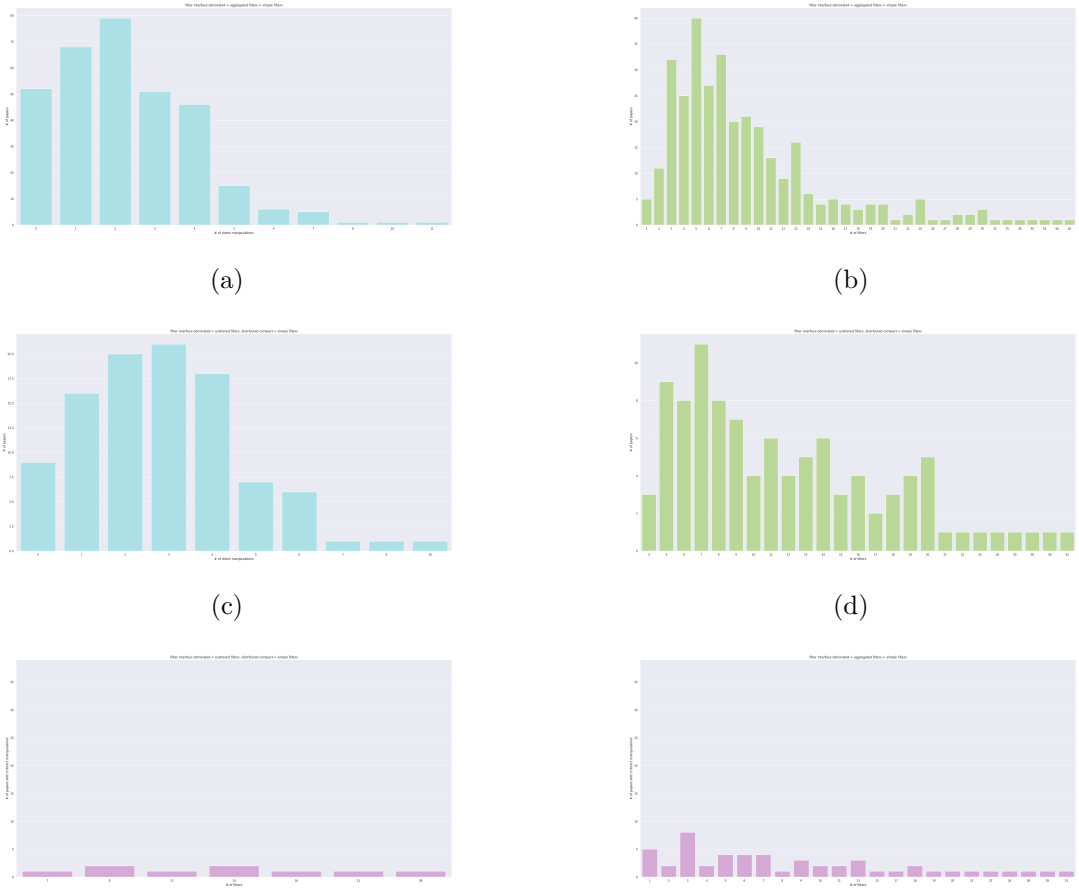
Figure 2: A1 analysis by taxonomic groups.

3 Analysis of filters and direct manipulation distribution (A2)

In analysis 2, the frequency distribution of the filters and direct manipulation was examined in detail, but the results obtained by rerunning the analysis for each taxonomic group are reported below. This allowed us to obtain a comprehensive overview of the trends in these categories.

The results obtained from the analysis by taxonomic groups were extremely consistent with those found in the global analysis. In general, it is observed that the number of filters used

usually varies from 1 to 14, while the number of direct manipulations varies between 1 and 6. However, the analysis of papers that do not use any filters (with 0 filters) remained unchanged as these papers are commonly grouped into a single category within the taxonomy. As regards the analysis of papers that do not present any direct manipulation, a greater variability is noted in the data compared to what was observed in the global analysis. This suggests that, within the scientific community there are different approaches and trends, while some works may opt for a limited use of filters, others may adopt a broader and more varied approach in interacting with filters.



(a) (b)

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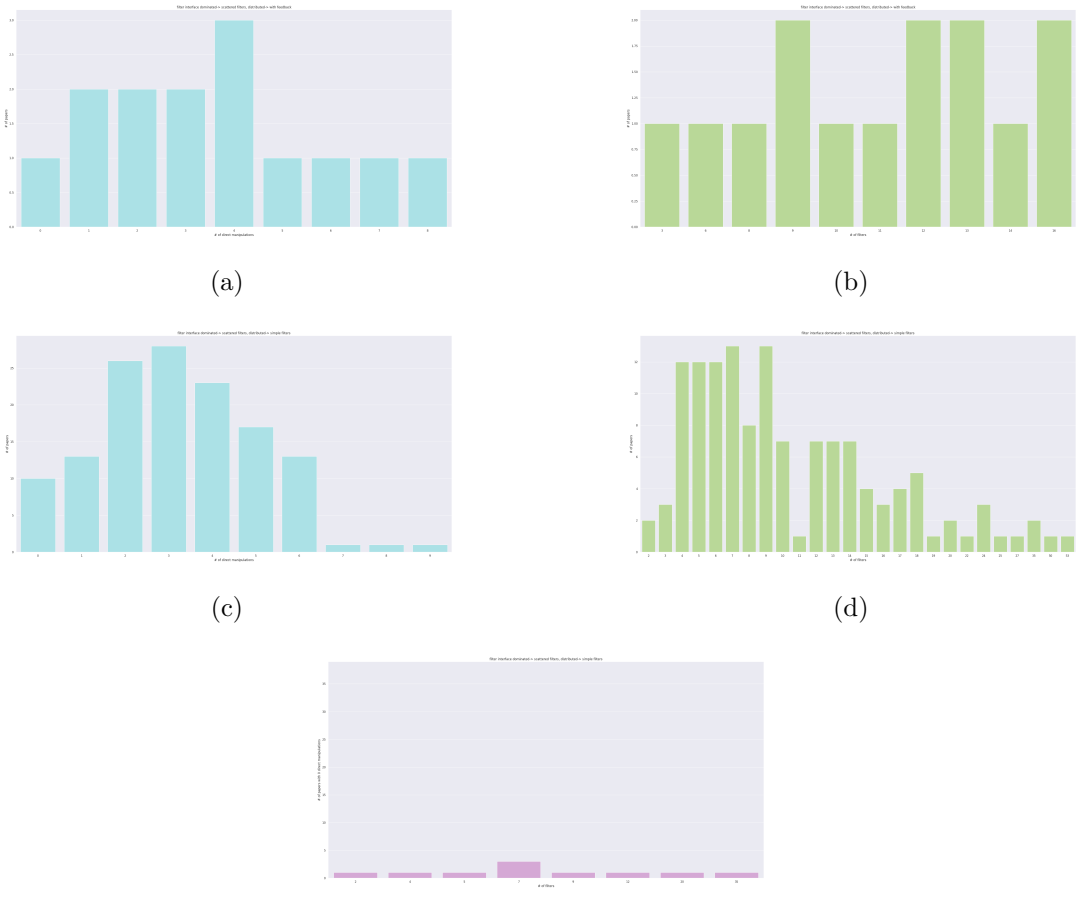
Figure 3: A2 analysis by taxonomic groups.



(a) (b) (c) (d) (e)

Figure 4: A2 analysis by taxonomic groups.

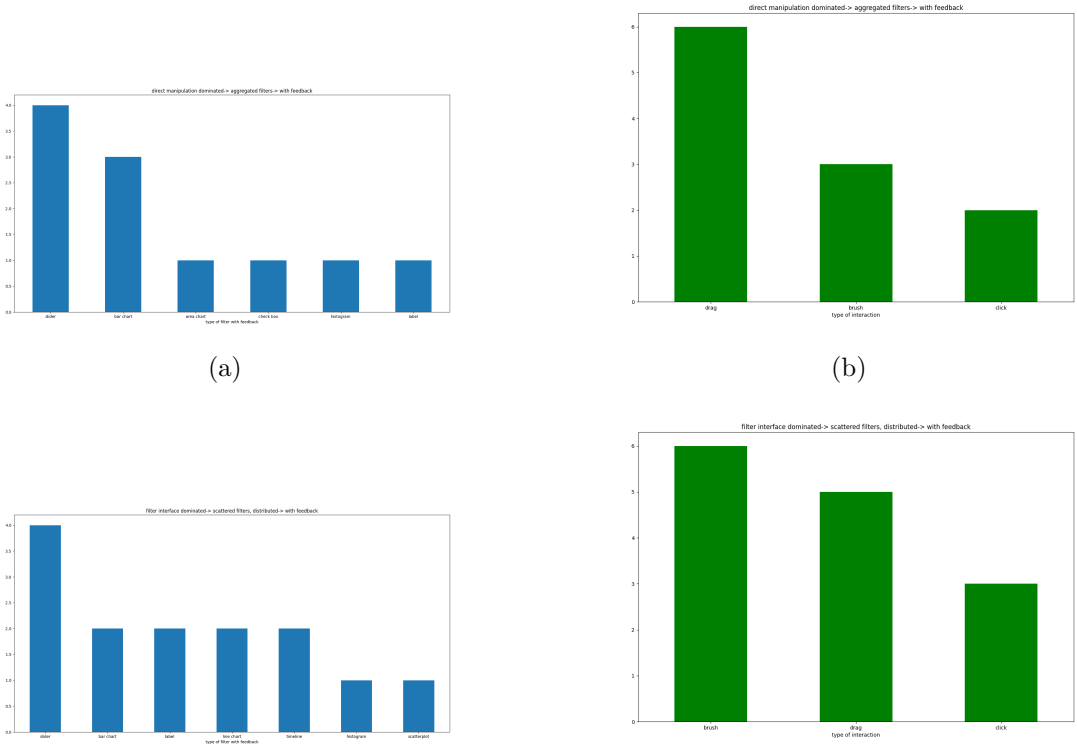
4 Analysis of filters with feedback and their user interactions (A3)

The analysis aimed to examine filters with feedback and user interactions when using these filters within data visualization systems. This analysis was extended to also consider taxonomic groups in order to better understand the differences and trends within each group. However, it is important to note that not all taxonomic groups returned the same results in the analysis, there was significant variation between groups in terms of the types of filters used and interactions with users. For example, some groups may have a greater prevalence

of sliders or labels as types of feedback, while others may show preferences for other forms of interaction.

The same goes for interactions with users, in fact, in some groups, there may be a predominance of brush or drag as the preferred interaction modes.

These differences between taxonomic groups suggest that preferences and practices in using feedback filters and user interactions may vary based on other parameters specific to each group, therefore, when designing data visualization systems or conducting research in certain sectors, it is important to take into account the specific preferences and tendencies of the taxonomic group of reference.



(a) (b)

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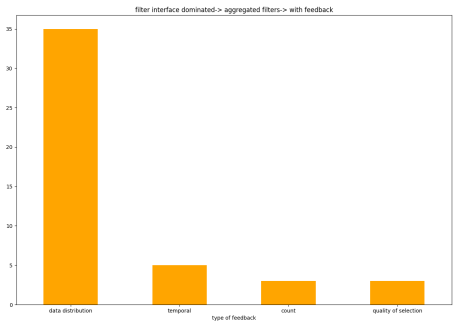
Figure 5: A3 analysis by taxonomic groups.

5 Analysis of the types of feedback (A3.1)

The analysis focused on examining the types of feedback implemented in filters within data visualization systems. This analysis was also extended for the taxonomic groups, in order to evaluate whether there were significant differences in the types of feedback implemented.
The results obtained from this analysis for each taxonomic group demonstrated consistency with the results of the global analysis; for each taxonomic group, a prevalence of "data distribution" was found as a type of feedback implemented in the filters.
This result suggests that, despite variations between groups in other aspects of feedback filters, the "data distribution" feedback typology appears to be widely adopted and used consistently across all contexts analyzed.



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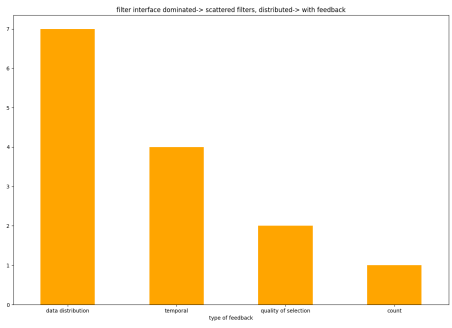
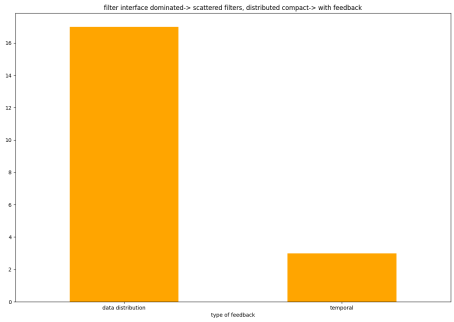


(b)



(c)

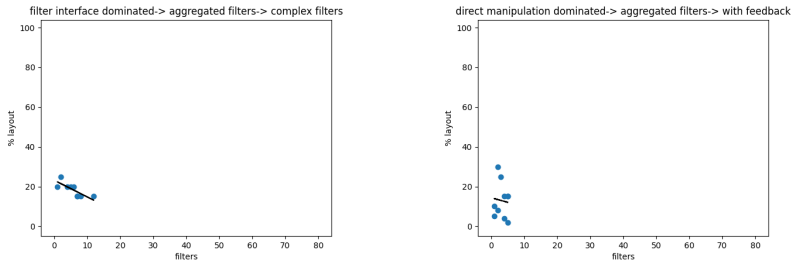
Figure 6: A3 analysis by taxonomic groups.

6 Analysis of relation between filters and percentage of layout they occupy (A6)

The analysis aimed to establish the relationship between the number of filters within a system and the percentage of layout they occupy. This analysis was extended to also consider taxonomic groups, in order to evaluate whether there were significant variations in the results.

The results obtained from the global analysis showed a directly proportional trend between the number of filters and the percentage of occupied layout. In some taxonomic groups, the results confirm the directly proportional relationship between the number of filters and the occupied layout, in line with the global analysis, however, in other taxonomic groups, an inversely proportional trend was noted. This means that in these specific contexts, as the number of filters increases, the percentage of layout dedicated to them tends to decrease rather than increase.

These differences highlight that each taxonomic group may have different needs and preferences, which suggests that interface design strategies should be adapted appropriately to meet the specific needs of each group.



(a) (b)

Figure 7: A6 analysis by taxonomic groups.

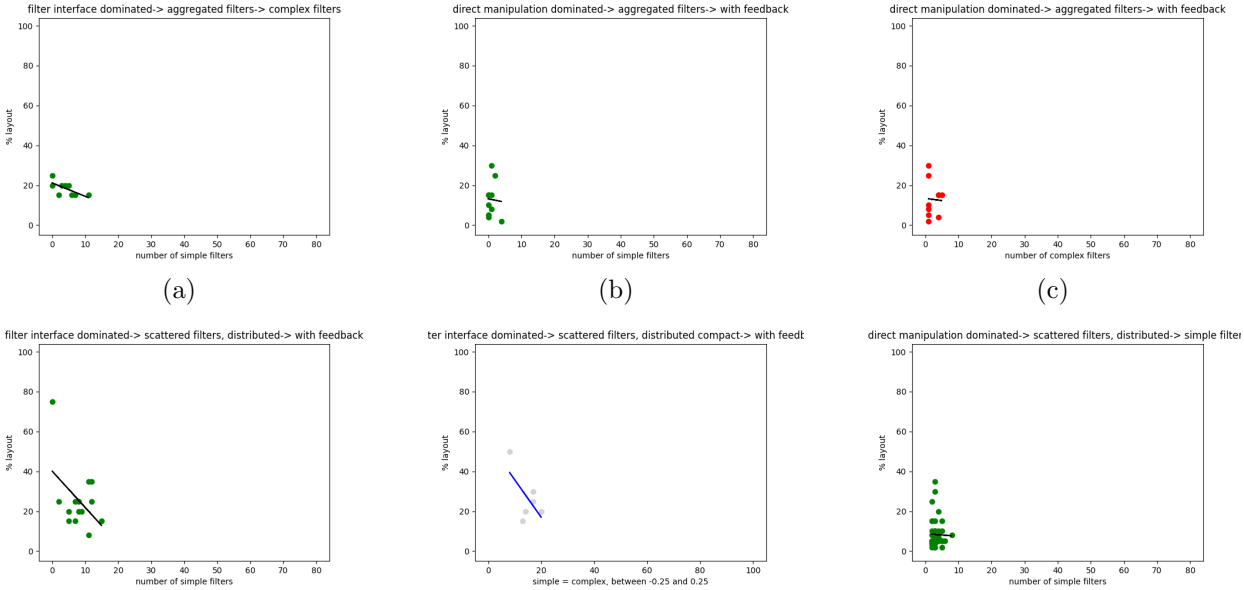


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Figure 8: A6 analysis by taxonomic groups.

7 Temporal analysis of filters and direct manipulation (A9)

Analysis 9 analyzed the time course of filters and direct manipulation, and was extended to analyze each individual taxonomic group. In general, the results obtained in these analyzes confirm what was observed in the global analysis.

Regarding filters, there is clearly an increase in the number of works falling into the "high" and "medium high" categories over time, indicating a growing adoption of more complex filters in user interfaces. On the other hand, regarding direct manipulation, an increase in the number of jobs in the "low", "medium" and "medium high" categories is observed over the years.

It is interesting to note that even for the analysis of the average of the number of filters and the direct manipulation for each taxonomic group, results consistent with what emerged from the global analysis are achieved.

This consistency in results suggests that the general trends observed in the use of filters and direct manipulation are consistent across different categories of systems and applications,

providing a more complete view of the evolution of user interfaces in this space.

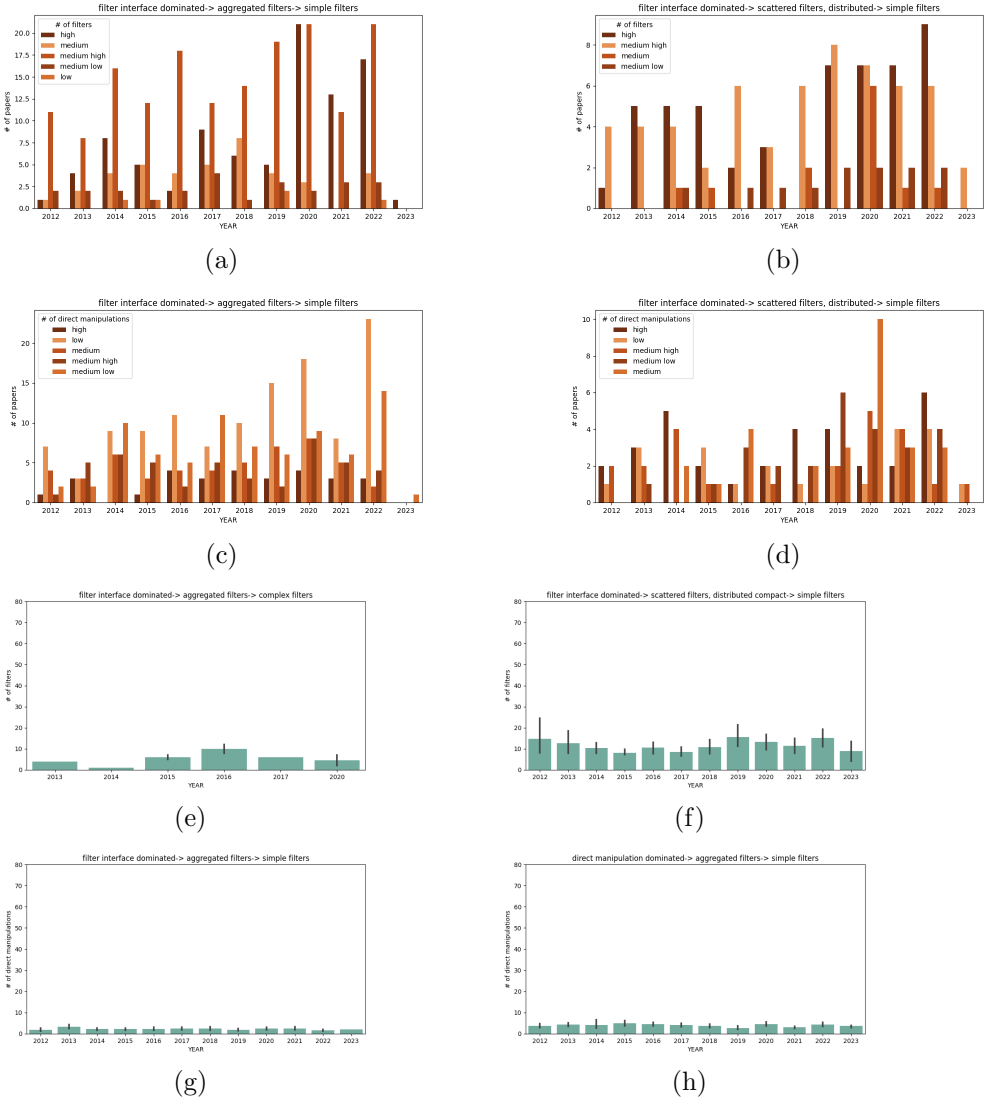

Figure 9: A9 analysis by taxonomic groups.

8 Temporal analysis on the layout occupied by the filters (A10)

Analysis 10, which focuses on the temporal trend of the percentage of layout occupied by filters, was also performed for each taxonomic group.

Interestingly, the results obtained in these analyzes for the different taxonomic groups are consistent with what was observed in the global analysis. In particular, over time, there has been a notable increase in works that dedicate a percentage of layout to filters that falls within the "medium-high" range. Furthermore, an increase, although less evident, is observed in the "low" and "high" ranges, while, as regards the annual analysis of the average trend of the layout percentage, it is interesting to note that there is a fairly constant trend, with small fluctuations over time.

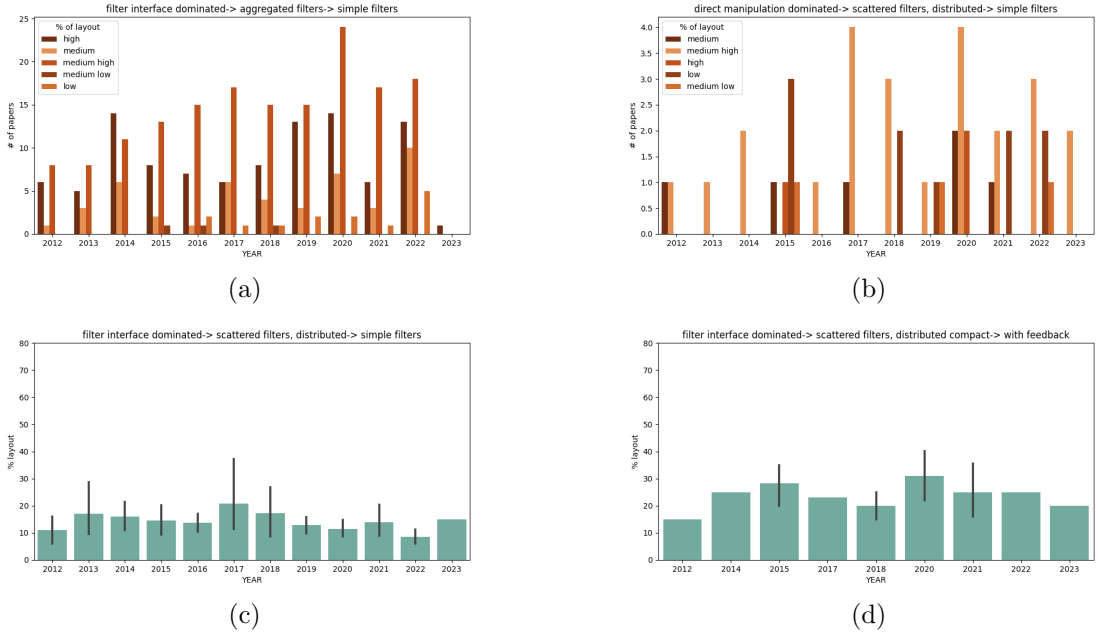

Figure 10: A10 analysis by taxonomic groups.