Automated Comparison of Scanpaths in Dynamic Scenes

Thomas C. Kübler and Enkelejda Kasneci

1 Introduction

According to the scanpath theory [6], the sequence of eye movements can give insights into the cognitive processes of visual perception. In this light, the comparison of scanpaths is of particular interest for many applications, e.g., driving [4], advertising, or activity recognition [1]. Although precise measurement devices and several approaches for the extraction of the visual scanpath in dynamic scenes exist, e.g. [7], the temporal and spatial comparison of scanpaths with their natural high variability remains challenging and laborious. Despite the variety of existing approaches, such as ScanMatch [2] or Multimatch [3], most scanpath studies are still limited to the comparison of time-integrated features, e.g. fixation duration or average saccade length. Due to the sequential nature of the scan pattern, such metrics are not sufficient to capture essential pattern characteristics of the viewing behavior. Recently, we proposed SubsMatch [5], a novel method for scanpath comparison in natural environments. In this work, we will demonstrate the performance of SubsMatch in comparison to the state-of-the-art when analyzing eye-tracking data derived from a driving scenario.

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2 SubsMatch Algorithm

Instead of addressing the issue whether two scanpaths focus on the same objects at the same time, SubsMatch addresses the question whether the scanpaths exhibit the same repetitive exploratory patterns. Figure 1 illustrates the main steps of SubsMatch as introduced in [5]. First, the scanpath is mapped to a string representation based on just one dimension of the scanpath, e.g. the horizontal position of fixations. Letter encoding is chosen to optimally map the scanpath data into equally frequent letters. This step also compensates for spatial offset and scaling, often caused by incorrect calibration, different seat positions while driving or different viewing distances towards the scene. The second step extracts all possible visual subpatterns from the encoded scanpath. The problem of scanpath comparison is thereby reduced to the comparison of the frequency of subpatterns.

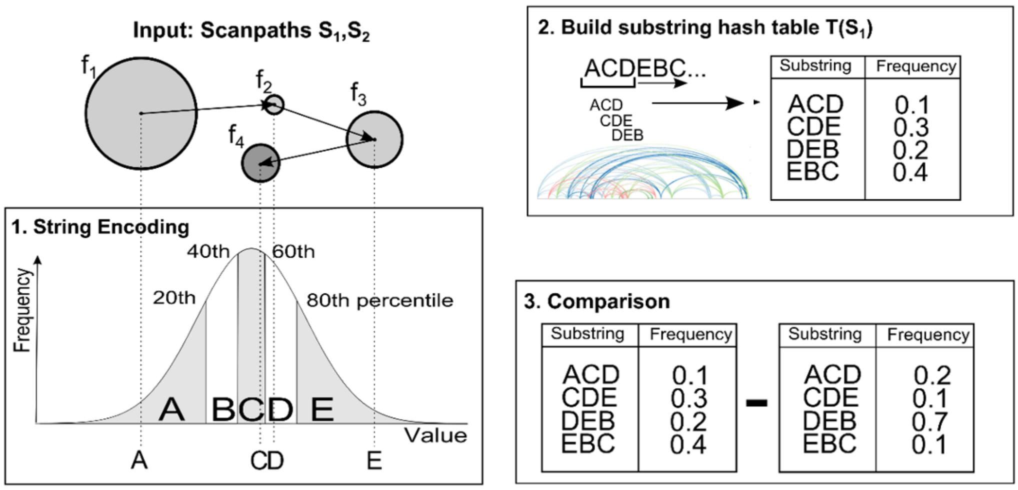

Fig. 1 Overview of the SubsMatch algorithm.

3 Exemplary Application

SubsMatch was applied to scanpaths derived from simulated driving sessions of 10 subjects with advanced glaucoma and 10 control subjects. Eye movements were recorded using a Dikablis eye tracker at 25Hz. 50% of the drivers with visual field defects were able to pass the driving test despite their visual impairment. This result indicates that the viewing behavior of patients who passed the test differs from the viewing behavior of patients who failed. Glaucoma subjects who passed (G_p) and failed (G_f) were compared to each other and to the control subjects (GC) to identify differences in the viewing patterns by means of SubsMatch, ScanMatch [2] and MutliMatch [3]. Table 1 shows the statistical evaluation of the pairwise scanpath

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Table 1 Comparison of the pairwise distances within and between scanpath groups (G for glaucoma patients, p/f for passed or failed the driving test, C for control subjects).

	$\{G_f, G_p\}$	$\{GC, G_f\}$	$\{GC, G_p\}$
SubsMatch	**0.03**	**0.03**	0.67
ScanMatch	0.05	0.05	0.65
MultiMatch	0.89	0.89	0.89

distances between the groups. SubsMatch revealed that there are no additional compensatory eye movements performed by the G_p group, as often assumed. Instead, this group was able to maintain a normal exploratory behavior, similar to that in the GC group. The G_f group on the other hand exhibit-ed fewer horizontal, alternating saccades.

4 Conclusion

The presented algorithm is a significant step towards automated analysis and comparison of visual scanpaths derived from eye-tracking data in natural environments. Beyond further developments of SubsMatch, our future work will focus on the question, how the analysis of recurrent patterns can be used to provide added value for several applications.

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