Happy or Sad, Smiling or Drawing: Multimodal Search and Visualisation of Movies Based on Emotions Along Time

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Abstract: Movies are a powerful vehicle for culture and education and one of the most important and impactful forms of entertainment, largely due to the significant emotional impact they have on the viewers, in our lives. Technology has been playing an important role, by making a huge amount of movies more accessible in pervasive services and devices, and helping in emotion recognition and classification. As such, it is becoming more pertinent the ability to search, visualize and access movies based on their emotional impact, although emotions are seldom taken into account in these systems. In this paper, we characterize the challenges and approaches in this scenario, then present and evaluate interactive means to visualize and search movies based on their dominant and actual emotional impact along the movie, with different models and modalities. In particular through emotional highlights in words, colors, emojis and trajectories, by drawing emotional blueprints or through users' emotional states, with the ability to get us into a movie in serendipitous moments.

1 INTRODUCTION

Movies have always had a very important role in society, and have become a powerful vehicle for culture, education, leisure and even propaganda (Shah, 2011). One of the main reasons is their ability to awaken the emotions of their viewers, to influence our moods, attitudes and consequently our health and wellbeing, making a difference in our lives. The success of each movie depends on the emotions that are perceived and felt by the audience (Aurier & Guintcheva, 2015); and the emotional information related to this experience that viewers have is actually considered an important factor when searching or seeking a film to watch, also determining its success (Arriaga et al., 2019; Zhang et al., 2009). Of particular importance is the safe environment provided to experience roles and emotions we might not otherwise be free to experience (Uhrig, 2005), and film has gained a uniquely powerful ubiquity within human culture (Shah, 2011), supported by pervasive services and devices.

In this context, the huge amount of movies or films we can access, and the important role of emotions, make more pertinent the ability to access, visualize and search movies based on their emotional impact. As a whole and along time: "As the frames move and tell a story, it is that movement which emotionally connects you" (Shah, 2011), and this is the journey, the path or emotional story, we want to capture and support. On the other hand, rich content of movies appeals to different senses, and the ubiquity in their access creates opportunities to use different devices, even in casual situations and environments, suggesting a multimodal access. Such situations may be when we want our current emotion taken into account, or want to draw an emotional path to search for in movies; possibly triggered by a music we are listening to, that moves us and reminds us of movies we like and how they made us feel; with the ability to get us into a movie in serendipitous moments.

In this paper, we characterize and discuss main motivation, challenges and approaches in this scenario, then present and evaluate interactive means to visualize and search movies based on their emotional impact, dominant as a whole or along the movie, with different models and modalities. In particular through emotional highlights in words, colors, emojis and trajectories, by drawing emotional blueprints or through users' emotional states in their facial expressions, with the ability to get us into a movie in serendipitous ways.

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2 BACKGROUND

In this section, we presents the most relevant concepts and related work, as a background and framework for our own work and contributions.

Emotions are complex sets of chemical and neural reactions that form a pattern and play a regulatory role, helping organisms to conserve life (Damásio, 2021). The study of emotion is complex and each emotional experience is personal and can involve several emotions (Cabanac 2002, Plutchik, 2001). Scientists have been trying to understand and explain their dynamics and arriving at several different models and definitions (Kleinginna & Kleinginna, 1981), with two main branches standing out: Dimensional; and Categorical, with discrete states that can also be represented in the dimensional models. Among the most adopted: Russell's Circumplex represents emotions in a two-dimensional space (VA) based on: Valence (pleasantness, x-axis); and Arousal (intensity & energy, y-axis) (Russell, 1980). Ekman's (1992) categorical model, based on the emotional facial expressions recognized across cultures, has happiness/joy, anger, fear, sadness, disgust and surprise as its basic emotions. Plutchik's (1980) 3D model is both categorical and dimensional (polarity, similarity, intensity), with 8 primary emotions: Ekman's 6, plus: anticipation, and trust, represented around the center, in colors, with the intensity as the vertical dimension (in 3 levels), that may also be represented in 2D as external levels going outwards, resembling a flower. The Geneva Emotion Wheel (Sacharin et al., 2012) is an appraisal based model (Scherer, 2009) organizing a set of 12 colored emotions around a circle with valence (x-axis) and control (y-axis) dimensions, and intensity decreasing towards the circle center. As a way to represent and express emotions, emojis have also become increasingly popular, in computer-mediated communication, and can be classified in valence and arousal (Fischer & Herbert, 2021).

Besides representing and visualizing **emotions**, doing so **along time** as movies progress and users experience different emotional impact comes with additional complexity and challenges. Timelines can help, but do not capture the dimensions of the emotion models; and these do not tend to support time. In dimensional models like Russel's, emotions can be represented on the wheel along time (with dots or small circles, drawing lines or painting), but in the end it is not easy to distinguish the trajectory followed, and it is not obvious to know if a long time was spent on the same emotion. Related work on trajectories and clustering can be of some help here.

Trajectories represent events over time and allow to highlight fundamental information (Dodge et al., 2008) like the path, speed, time at a certain point and, through colors, how it evolved **over time**, e.g. through fading. FeelTrace (Cowie et al., 2000) (Fig.1a) lets users track perceived emotional content of speech in realtime, using an activation-evaluation space (similar to arousal-valence), naturally circular, with neutrality at the center. TimeWheel (Tominski, 2004) (Fig.1b) also repesents time within a circular shape, though not a wheel of emotions. In (Cruz & Machado, 2016) (Fig.1c), the authors adopt a semantic figurative metaphor of pulsing blood vessels to visualize Lisbon traffic, seeking a provocative perspectives and trying to invoke emotional responses. In (Jorge et al., 2014) (Fig.1d), georeferenced videos were represented in space and time by their trajectories on maps,

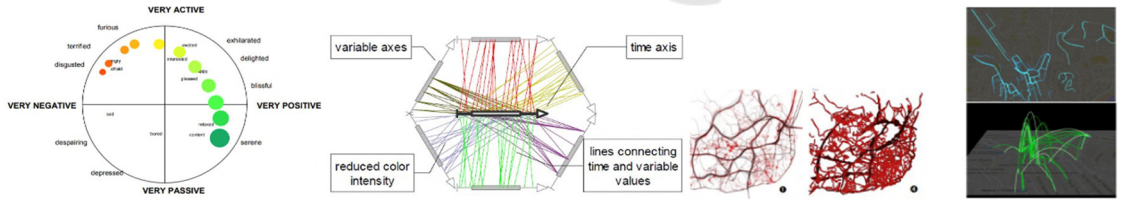

Figure 1: Temporal representations: a) FeelTrace (Cowie et al., 2000): Plutchik's colors used for axes extremes, and emotions in circles with color interpolated by those on the axes. Time is represented as circles shrink gradually over time, providing a visual indication of the way ratings changed. Interesting, but conflicts if circles' size has another meaning; b) TimeWheel (Tominski, 2004): Instead of a time wheel, it represents a central axis for time, and organizes around it the dependent axes or variables (as multidimensional data), connecting by colored lines the variable with its corresponding time, for an intuitive perception of time dependencies; c) Pulsing Blood Vessels (Cruz & Machado, 2016): Clots represent slow traffic and blood vessels represent number of vehicles (making vessels thicker) and average speed circulating in the city (faster, shorter); d) Video trajectories (Jorge et al., 2014): georeferenced videos were represented in space & time by their trajectories on maps, emphasizing amount of videos in the different routes (by brighter & thicker blue lines), as well as the speed the trajectories were filmed (higher arcs: more video shooting, thus slower pace), and their age (fading bright green of trajectories over time).

emphasizing amount of videos in the different routes, speed the trajectories were filmed), and their age.

The ability to **Search** is paramount especially in large information systems; it is usually based on properties or keywords, and it is often possible to browse the results in search, exploratory and serendipity browsing (Chambel et al., 2013; Chen, 2010). **Information Visualization** (IV) may help to deal with data complexity in intuitive and effective ways to express meaningful information (Aigner et al., 2011; Tufte, 1983). As such, IV goes hand in hand with search, to provide good representations for the results and browsing. Although this emotional perspective has been gaining attention, most websites and movie search and recommendation systems like IMDB, Netflix or HBO, do not support emotions. Instead, they search for films by actors, directors, ratings, genre, etc; and recommend based on popularity, most watched movies, and genre similarities. We present both commercial and research-based search systems with more representative goals, as well as emotion-based search, access and visualization interfaces.

MovieWall (Nefkens, 2017) is an interactive browsing interface placing **movies** in a cluster of posters and highlighting them according to search criteria like genre, actor, producers or keywords. Search by color is also relevant, especially when mapping the **colors** to emotions. Multicolr (https://labs.tineye.com/multicolr) searches images by up to five color percentages, that the user can adjust. ColorsInMotion (Martinho & Chambel, 2009) explores and views videos based on dominant color and **movement** (rhythm), with different visualization and summarization approaches. As for movement and trajectories, in SightSurfers (Serra et al., 2014) we proposed multimodal interactive mobile interfaces to search and access georeferenced videos based on trajectories' **shape** and **speed**, and by **time**. No emotional dimension was explicitly supported for these videos, but a potential for emotional impact through increased engagement, sense of presence and immersion (Ramalho & Chambel, 2013); and this approach might inspire the search for movies with specific emotional trajectories in a wheel. Movie Clouds (Chambel et al., 2013) on the other hand used color to index or associate tag clouds with content (subtitles, emotions expressed in the subtitles, audio events and music mood), or **emotional impact** (based on sensors and Ekman's emotions with Plutchik's colors, as in iFelt (Oliveira et al., 2011)) on the movie timeline; and allowed painting a timeline to search for movies with that sequence or trajectory of content or impact. MEMOSE (MEdia EMOtion SEarch) is specialized in emotional search (based on tagging **pictures** with eighteen emotions), along with content tags (e.g. love and dogs) (Jorge et al., 2014). Movie Emotion Map (Fig.2) goes further and aims to better understand the emotional space of **films** along with additional information (Cohen-Kalaf et al., 2021).

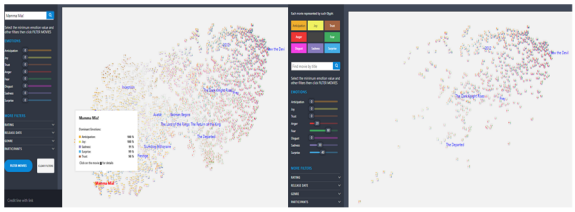

Figure 2: Movie Emotion Map overview (left) and search by emotions filter (right) (Cohen-Kalaf et al., 2021): It creates emotional signatures for each movie, based on the words in IMDB reviews, and the Plutchik's model (Bader et al, 2017). Glyphs of different colors and intensities for emotional values are mapped onto a 2D graph, allowing users to search, view and interact with films according to the % of desired emotion and criteria like rating, genre, etc. Results: highlighted on map with title in red and movies with most similar emotional signatures.

3 SEARCHING AND VISUALIZING MOVIES BASED ON EMOTIONS

This section presents main features to search and visualize movies based on emotions being designed and developed for the main web application of the AWESOME [2] project. The emotional impact on viewers is being assessed while they watch the movies, to provide feedback and to catalog the movies: based on biosensors like EEG, EDA, and a webcam for facial expressions; and by having users engaging in self-assessment and annotation of the movies, using different models or interfaces like categorical emotions, maniken and emotional wheel (both based on the VA dimensions) (Nunes et al., 2022); and articulating with other project tasks where video content-based features are extracted mostly in audio, subtitles and image.

This application is also integrating our previous As Music Goes By (Moreira & Chambel, 2018; 2019), allowing users to search, visualize and explore music and movies from complementary perspectives of music versions, artists, quotes &

[2] AWESOME Project: Awareness While Experiencing and Surfing On Movies based on Emotions

movie soundtracks. In this paper, we emphasize a perspective driven by Movies, by the name of As Movies Go By. In the following sections, we present and discuss our emotional model approach, that we aim to keep rich and expressive, though effective, flexible and easy to understand; and (by the order they were evaluated by users) the movie search and visualization features, based on their emotional impact, as a whole and along time, with multimodal interfaces for different contexts of use.

3.1 Emotion Models and Representations

We are adopting Russel's VA circumplex, or wheel, as the central model, where we color the wheel and also place categorical emotions (in words or emojis) to help convey more meaning. When using EEG, ECG or EDA sensors, the emotions are classified in VA by our classifiers; when using the webcam, users' facial expressions are recognized in relation to the Ekman's 6 basic emotions, and are most naturally expressed by emojis. In any case, as long as the categorical emotions are associated with a VA, and a color map is defined for the wheel, representations can be converted among each other (only rounded up when the output precision is lower: e.g. VA to the nearest categorical emotion). We provide some default mappings (e.g. Plutchik or Geneva) to choose from; and, for flexibility and personalization, are developing an interface for customizable wheels, defining: the categorical emotions, their VA, colors (by individual emotion, or the whole wheel color map or image) and emojis. In Fig.5a), we exemplify the wheel created for the VA and colors of the main 8 emotions in the Plutchik Model: 6 from Ekman, plus Anticipation and Trust.

3.2 Multimodal Searching of Movies by Emotional Impact

Several views were designed, for Search by Dominant Emotion or by Emotional Trajectory, with the output representation matching the input, in different modalities; and giving access to the individual movies in the results, where they can be explored and watched along with their emotional visualizations, as described in section 3.3.

The search menu is presented at the top of the **Homepage** (Fig. 3 a), where the user can visualize the trailer and information about a random movie, that can be changed, also at random, by button click. The objective of this feature is to introduce the users to movies that they may not know or may want to revisit and watch, as a flavour of surprise and serendipity. The search methods based on emotions are available in a menu and they trigger popup windows (Fig.3 b1-c1, Fig.4 a1-b1).

Search by Dominant Emotion can be done in three ways: by categorical emotion words (Fig. 3 b1), by emojis or facial expressions on camera (c1) and by colors in wheel (d1). In all of them, the user can choose up to five emotions by clicking (in words, emojis or wheel) making them colorful, and the emotion bar filled with colors (if words and wheel) or emojis; the user can then adjust the bar to the % amount desired for each chosen emotion, working similarly to Multicolr (https://labs.tineye.com/multicolr) that allows an image search based on color where users can select up to five colors and adjust their respective percentages

Figure 3: As Movies Go By - Homepage (a) and Movie Search by Dominant Emotions: Search Queries: b1) Categorical emotions in words, c1) Emojis and Camera, d1) Colors in Wheel; Search Results: b2) Categorical emotions in words with complete movie information, dominant emotion with emojis, dominant emotion on wheel.

by dragging the borders. The emojis and categorical emotion words chosen also change their size based on the % they have.

For the emojis (Fig.3 c1) if a camera is available, users may also click on the camera icon to turn it on, and have their facial expressions analyzed in real time and presented on the bar as %s of the emojis representing Ekman's emotions [12], a well-accepted model, one explicitly associated with universal emotional facial expressions, recognized across cultures. In the wheel, circle size reflects the amount of time it was clicked, and the % time the emotion was felt, and can be adjusted in the bar. In this view, the circles represent the nearest categorical emotion, represented by colored sectors in the emotional model in Fig. 5.1 (but could be customized differently (sec. 3.1)).

Search by Trajectory can be made in two ways: by free drawing (continuous trajectory) (Fig.4 a1); or by discrete points (Fig.4 b1). In the free drawing search method, the user can draw a line on the wheel with colors and VA associated with the emotions along the wheel. This line represents a segment of emotions which are searched, starting from the beginning of each movie stored in the database. The discrete points are very similar, but instead of drawing a continuous line, users click on the wheel at several points to create circles representing the corresponding emotions' VA, and connected by straight lines to create a path.

Search Results (Fig.3 b2-d2 and Fig.4 a2-c2) by default are represented in a format that matches the input. When the user searches by emojis or categorial emotions, the user input is displayed followed by a list of the resulting movies (Fig.3 c2), with common information (like title, synopsis, director and cast) and emotional information, including: the three most dominant emotions shown as tag clouds and emojis; as a colored vertical bar (not to be confused with timelines) ordered bottom-up by emotions' %; and a bar in one average color (a weighted average of the dominant emotions). We chose the top 3 emotions to display, reflecting some diversity but not too much, like in a podium, and inspired by Miller's research on

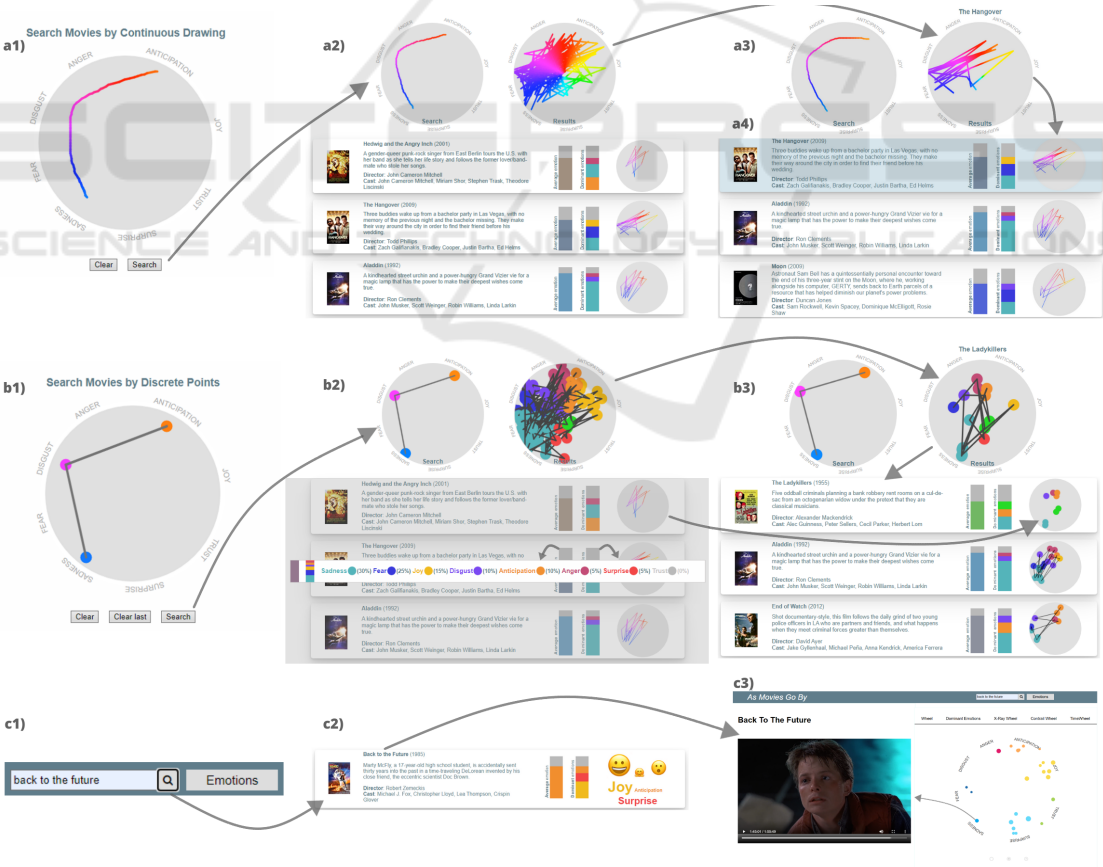

Figure 4: Movie Search by Trajectory: Search Queries: a1) with free drawing, b1) with discrete points; Search Results: a2) with free drawing, b2) with discrete points; a3) Individual movie trajectory representation on wheel; a4) Highlighted movie selected on wheel; b3)Movie trajectory replay; c1) search by title query; c2) and results list; c3) movie visualization.

cognitive load (Miller, 1956), that suggests 7+-2 items (also taking into account that we have 3 different ways to present the same emotion (word, color and emoji)).

We then noticed that besides podiums, three is a number adopted e other selections, like the number of reactions highlighted for posts and comments e.g. on Facebook; so this choice appeals to familiarity).

When there are more than 3 emotions, the bars display a gray section at the top for the remainder %. The user can also click on one of these bars to display a more complete emotional information about the movie (Fig.3 b2). When the search is made by wheel, the input is displayed along with another wheel containing all the dominant emotions of the results in the current page (Fig.3 d2); and below is displayed a list with the respective results (10 per page) with a smaller wheel representing the movie dominant emotion, instead of the words and emojis.

The **trajectory** search results are displayed in a similar way as the method described for the wheel: the user input is displayed along with another wheel that has all resulting trajectories (in the page) together (Fig.4 a2,b2), and below in the list, each movie has the correspondent trajectory. In the trajectory results view, the user can also click on the results wheel to replay each movie trajectory individually (Fig.4 a3,b3) and then click on one of them to scroll down to the respective movie (Fig.4 a4). The movie trajectory in each movie result can also be clicked to animate the way its trajectory progresses, segment by segment (Fig.4 b3).

The user can also do a search **by movie title**, in the top search bar (Fig.4 c1). In all results displayed, regardless of the search method, the user can click on the movie poster or title (Fig.4 c2) to proceed to its visualization (Fig.4 c3), as described in section 3.3.

Multimodal Search: To support more natural interaction and serendipitous moments, users may search by drawing emotional highlights (as dominant emotions) and trajectories (as emotional stories); and by the user emotional expressions detected with a camera (described above). And we are also exploring the search by music being played, to access the music detected, the movies featuring this music and those with similar emotional impact (Caldeira et al., 2022).

3.3 Visualizing Movie Emotional Impact Along Time

In the Movie Visualization page, the movie plays on the left, side by side with the Emotional Views on the right (selectable by the tabs above): the Emotional Wheel in Fig.4 c3), and the other views in close-ups in the next figures. In this case, Back to the Future is playing, and the user just clicked on a circle representing a sad emotion on the wheel and was directed to the corresponding scene where this sad emotion was felt: when Marty McFly, back in 1985, thinks that Doc has died... If you haven't watched the movie, we won't spoil it for you. But we will present the visualizations.

In previous work, we visualized emotions with tag clouds, charts and colors for categorical emotions; colored circles and painted trajectories on the VA wheel; and video timelines painted with colors mapped from the wheel (that could be shown in synchrony with the wheel (often on the side) when the movie was playing, or inspected on hover) (Nunes et al., 2022). But a couple of challenges remained for: **#1)** the **timing** of emotional trajectories on the wheel: they represent visited emotions, but how to represent the time direction and speed?; **#2) stationary** or **overlapping** spots: how to distinguish when the same emotions are felt for a long time or again at different times?

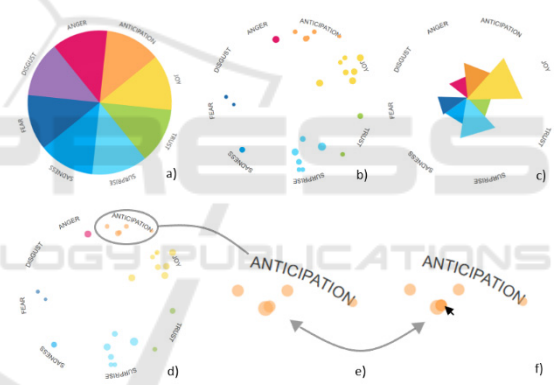

Figure 5: a) Wheel for the 8 central emotions in the Plutchik Model; b) Emotion wheel; c) Cumulative Dominant Emotions wheel; d) Emotion Wheel with transparent overlaps; e) and f) changing transparency on hover.

The **Emotion Wheel** (Fig.5b) is used to represent the emotions on the wheel in their VA positions (as captured, for accuracy), with the circles adopting a color in accordance to their position and identified as the closest categorical emotion. Observe the total number of circles of an emotion and their size and it is possible to realize that the emotion Joy (although with neighbour circles at different VA values) is the dominant one. This can be confirmed in the **Cumulative Dominant Emotions Wheel** (Fig.5c), where each sector represents the frequency and how much time (in %) the user felt each emotion, addressing challenge #2. Challenge #1 only in play mode, when it animates the evolution. The visible

colors are the ones that were felt; another option would be all in the current model (for a more complete contextualization), using transparency for absent ones (in a way closer to Plutchik's in (Semeraro et al., 2021).

To address challenge #2 of overlapping emotions, another view was created with the circles made more **transparent** in relation to the normal wheel, to make the **overlaps** noticeable. When hovering the circles, they loose transparency, helping to check these overlaps as the circles stand out (Fig.5e-f).

To help identify **how time goes by** (challenge #1), when telling the user's emotional stories about watching a movie by the represented paths on the wheel: the emotional views may be watched in realtime, in sync with the video being played (Nunes et al., 2022); they can be Replayed a posteriori, e.g. redrawing the circles, at a faster pace; and the final representation on its own may also provide some help.

In the Emotion Wheel (Fig.6a-b), besides the drawing of the emotion circles, a trajectory can be represented by lines between circles, to reflect how the emotions were felt along the movie. But it does not address all the challenges inherent in #1 (e.g. where it starts or how long spent) when in animation. For stronger solutions, we adopted a couple of **metaphors** in our design, depicted in Fig.6-7.

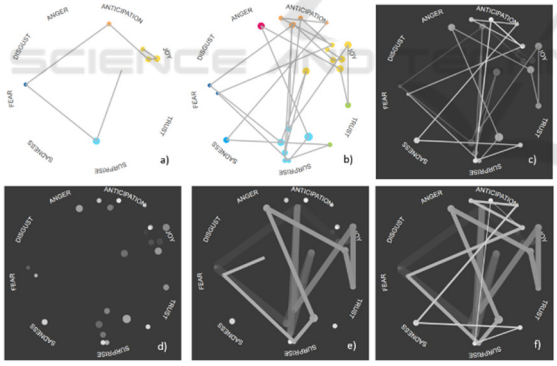

Figure 6: Emotional Trajectories: in Emotional Wheel: a) trajectory in progress; b) final state; in X-Ray view: c) lines d) circles; in Contrail view: e) in progress f) final state.

The **X-Ray** metaphor was adopted as a solution, where the evolution is presented through the fading of a single color on the path (whiter to darker gray), that is, we ignore the colors of the wheel and focus on the "skeleton", highlighting the more recent (for challenge #1). Transitions between discrete emotions are represented by lines, and emotions by circles (Fig.6c-d). In crossovers, when returning to a previous emotion, the new circle on top will adopt the most recent color. On the other hand, the circle size (and the speed in the replay along time, in all the views) reflects the amount of time the user has felt that emotion. In this view, there is still the possibility for the user to see the emotional evolution only through circles (Fig.6d).

The **Contrail** metaphor (Fig.6e-f), refers to the trail of condensation an airplane leaves behind when it flies, due to differences in temperature, making it possible to observe the recent path it took to where it is. The trail is narrower close to the plane and is wider and more disperse at more distant points, and this is what is represented in Fig.6f from the oldest to the newest emotion, reinforced with the color becoming whiter and less transparent and the lines narrower, making possible to visualize this passage of time. For example, in Fig.6e the "plane" (the current time) is located close to the middle of the wheel, and the line there is the whiter, more opaque and narrower so far.

The **Emotion TimeWheel** addresses challenges: #1 by mapping the emotions on the wheel onto the timeline; and #2 by the size of the circles (influenced by the total time that emotion was felt) and the length of each segment on the timeline (the same emotion possibly mapped more than once at different times), making it possible to verify which emotions were felt for the longest time and in what order.

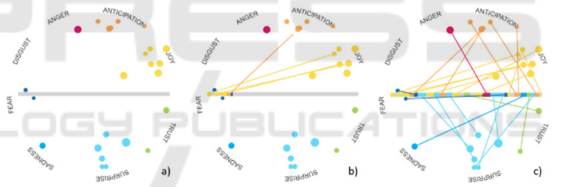

Figure 7: TimeWheel: a) initial state in Replay; b) mid-way representing timeline, identifying emotions; c) final state.

In Fig.7a) the visualization is in its initial state, with only the circles and the empty timeline. In Fig.7b), the animation is in progress and it can be noticed that the sectors are being formed as a line links each sector to the corresponding circle. In Fig.7c), the animation is in its final state making it possible to see the full emotional story of the movie.

4 USER EVALUATION

A user evaluation was conducted to assess perceived usefulness, usability and user experience in the search and interactive visualization features to access movies based on emotions in As Movies Go By.

4.1 Methodology

A task-oriented evaluation was conducted, with semi-structured Interviews and Observation while the users performed the tasks with the different features and visualizations, after explaining the purpose of the evaluation, asking some demographic questions and briefing the subjects about the application. For each task, we observed and annotated success and speed of completion, errors, hesitations, and their qualitative feedback through comments and suggestions. An evaluation based on USE (Lund, 2001) for the tasks was adopted, rating perceived Utility, Satisfaction in user experience and Ease of use on a 5-point scale.

At the end, users were asked: to provide a global appreciation of the application, through a USE rating; to highlight the features or properties they appreciated the most, and suggestions for what they would like to see improved or added in the future; and to characterize the application with most relevant perceived ergonomic, hedonic and appeal quality aspects, by selecting pre-defined terms (Hassenzahl et al., 2000) that reflect aspects of fun and pleasure, user satisfaction and preferences.

4.2 Participants

This study had 10 participants, 6 male, 3 female and 1 non-binary, 22-55 years old (Mean 33.4, StdDev 13.8); all of them have college education (3MSc, 7BSc), coming from diverse backgrounds (5 Computer Engineering, 1 Arts, 1 Mathematics, 1 Medicine/Radiology, 1 Administration and 1 Special Education); all having moderate to high acquaintance with computer applications, and this one being their first contact with this application, allowing to discover most usability problems and to perceive a tendency in user satisfaction.

Participants watch movies weekly (5), monthly (2), occasionally (2) or daily (1); using mostly streaming platforms such as Netflix (9): weekly (4) and daily (2); and television (9): weekly (4) and daily (1); and cinema (9): occasionally (7) and monthly (2); open access websites (5): occasionally (3), monthly (1) and daily (1). Most of them search for information about movies monthly (4) or occasionally (4), others weekly (2), daily (0) and never (0). The criteria they take into account to choose a movie: genre (9), actors (7), directors (5), and most popular at the moment (5). Almost everyone completely agreed (7) that viewers can feel emotions by watching movies; and they sometimes (4), never (3), a few times (2), and a lot of times (1) use movies to change their emotional state. When participants were asked to associate movie genres with the emotions they represented, there was a concensus (90%) associating comedy with joy, and horror with fear.

Participants were also asked if they ever used any movie or related application based on emotional states. One computer engineer said he had used Happify, aimed at wellbeing, encouraging users to connect with their thoughts and feelings using cognitive behavioral therapy skills (like savoring, thank, aspire, give, empathize and revive) and positive psychology; and Daylio, a diary and mood tracking app based on mood (in 5 levels: rad, good, meh, bad, awful), employing startegies like reminders and achievements. These are somehow related, but not using emotions per se or movies in a very explicit way. The majority of participants never used one such application, but would like to use, giving some insight of what they would like to find, such as movie search or recommendation according to users emotional states, and automatic emotion recognition (something that we are already exploring here and in other parts of our work).

Table 1: USE evaluation of As Movies Go By.

Task	U		S		E	
T# Feature	M	SD	M	SD	M	SD
1 Home: random movie	**4.3**	1.3	**4.2**	1.1	**5.0**	0.0
2 Search and Results *(mean)*	*3.7*	*1.0*	*3.8*	*0.8*	*3.9*	*0.7*
2.1 by Emotions in Words	**4.2**	1.1	**4.3**	0.8	**4.4**	0.7
Results	**4.1**	1.3	**4.1**	1.1	3.9	0.9
2.2 by Emojis and Camera	3.9	1.2	**4.6**	0.7	3.7	0.7
Results	3.2	0.8	3.5	0.5	3.8	0.6
2.3 by Colors in Wheel	3.3	1.2	3.2	0.6	3.3	0.7
Results	3.5	1.4	3.5	1.2	**4.4**	0.7
2.4 by Trajectory Free Drawing	2.8	0.9	3.0	0.9	3.4	0.8
Results	3.2	0.9	3.2	1.1	2.7	0.8
2.5 by Trajectory Discrete Points	**4.3**	0.8	**4.3**	0.9	**4.7**	0.5
Results	3.5	1.0	3.5	1.0	3.5	0.7
2.6 Search by Title	**4.8**	0.6	**4.7**	0.5	**4.9**	0.3
3 Movie Visualization *(mean)*	*3.7*	*1.1*	*3.7*	*0.7*	*3.7*	*0.6*
3.1 Wheel View	3.6	1.0	3.5	0.7	3.2	0.6
3.1.1 Overlays	3.8	1.4	3.4	0.7	3.4	0.7
3.1.2 Time and Trajectory	3.6	1.3	3.9	0.9	**4.1**	0.7
3.2 Dominant Emotions View	**4.0**	1.3	**4.2**	0.8	**4.5**	0.7
3.3 X-ray View	2.9	0.9	2.9	0.3	3.0	0.5
3.4 Contrail View	3.4	0.7	3.6	0.7	3.8	0.6
3.5 TimeWheel View	**4.4**	0.8	**4.1**	0.7	**4.0**	0.5
Global Evaluation	3.7	0.7	3.9	0.6	3.8	0.4
Total per Task (mean)	*3.9*	*1.1*	*3.9*	*0.9*	***4.2***	*0.4*

(Scale:1-5: lowest-highest); M=Mean; SD=Std. Deviation)

4.3 Results

The users finished almost all the tasks quickly and without many hesitations, and generally enjoyed the experience with the application. The results are presented in tables 2 and 3 and explained in the text, along with the comments made by the users.

Homepage. At this page, we asked the subjects *'to change the random movie and watch its trailer and information'* to evaluate this interactive feature. We had quite positive results for USE (U:4.3; S:4.2; E:5), also presented on table 1. Users found the feature "very good to suggest movies" and "a good way to choose movies when you're not sure what to watch". Another user said it could be interesting to have a movie randomizer filtered by dominant emotion, since this emotional information is presented.

Search and Results. For this part of the application, we created tasks for the 6 methods of searching movies and their respective results.

In T 2.1, users were asked *'to search movies by dominant emotions in words with the input of Joy (79%) and Sadness (21%)'*. Their response was very good with majority completing the task quickly. Most of the users found this search method "easy to execute and useful" with a couple saying that "percentages were too specific", i.e. no need to be so accurate, though recognizing that it is important to specify dominance and this is a good way to do that; or that the interface could "have more emotions to choose from", which is aligned with what we are doing, making the emotion model customizable (section 3.1). Overall, the opinion on this task was quite positive (U:4.2; S:4.3; E:4.4). Regarding its results, users were asked *'to name the most and least dominant emotions in the first result presented'*. They found the way the results were presented "interesting, especially the emotional information", and concluded very quickly what was the most dominant emotion. When trying to find the least dominant emotion, the users struggled a bit at first, as they did not know they had to click the dominant emotions' bar (having more than 3 dominant emotions, as indicated by the gray bar on top); then it was ok, and the rating was (U:4.1; S:4.1; E:3.9).

In T2.2, the users had to *'turn on the camera and express the emotions of Joy and Surprise in their faces';* and *'change the values to 84% and 16% respectively'* in the emojis (and these could also be selected without the camera). The reaction was very positive with comments like: "very interactive with the user", and "loved this functionality, would like to see in future apps". The only downside was that "some emotions are difficult to represent with facial expressions", especially when thinking about a broader set (in the ones used, 6 are from Ekman, corresponding to emotions that are easily recognized in facial expressions, even across cultures; Trust and Anticipation (added by Plutchik) being more challenging to express). But overall was a "very good experience" (U:3.9; **S:4.6**; E:3.7). The results were presented in a similar way as the previous search method, but here the participants were asked to *'say which emoji corresponds to each emotion and to interpret the Average Emotion bar'*. Most of them could identify the emotion of each emoji with ease, but several failed when interpreting the average emotion (something that they were not familiar with), then deeming it "not very useful". Though one person thought that "it's useful to know which type of movie it'll be". These results got (U:3.2; S:3.5; E:3.8).

Task T 2.3 was the last task to search for Dominant emotions, this time by Colored circles in a Wheel. The users were asked to *'draw two circles on the wheel (presented to them in an image), by clicking on the wheel, one around the Joy emotion area and another around the Trust area'* (color would be automatically assigned based on the position), and then *'adjust the percentages to 78% and 22% respectively'*. Generally, the participants thought that "the previous methods were more intuitive than this one" because "when using it for the first time, it's not easy to know how it works" (U:3.3; S:3.2; E:3.3). In the results, the users had *'to identify the dominant emotion in the wheel'*, and they found it "easy to understand" but "the results wheel, on itself, makes it more difficult if movies have emotions in overlapping positions", something we are already dealing with and testing in other views. (U:3.5; S:3.5; E:4.4).

In the first Trajectory Search method, by Free Drawing in T 2.4, the users were prompted with an image with a continuous line representing *'an emotional trajectory, within a movie, that they had to draw'*. Overall, the participants found it reasonably satisfactory and easy to use (S:3.0; E:3.4); but not so useful (U:2.8), a few saying: "it's not common or mainstream"; "it's not relevant to draw the trajectory this way". It was easier for them to think of the individual emotions, even when in sequence (next task), although it may be something they get to appreciate more as they use it. In the results view, they had to *'observe each trajectory individually in the results wheel (at the top) and choose one, then replay the trajectory of the chosen movie'*. The participants struggled to understand how it worked, hence the E score (U:3.2; S:3.2; E:2.7), because "there is no indication that the wheels can be clicked

to replay the trajectories"; and "it's not useful to have all trajectories mixed up"; the users also pointed that "each movie wheel in the list should have the emotion labels, as presented in the search and results wheels", not presented to make the list lighter. But they liked trajectories shown in sequence, and the list of results.

In the second trajectory search method, by Discrete Points in task T 2.5, users had to do a similar search as before but with a different image prompt (with circles for each emotion in the trajectory) they drew by clicking. They found it more "appealing and simple" and "more intuitive and satisfying than the free drawing method"; "it's the best way to represent emotions on a wheel [separately]" (U:4.3; S:4.3; E:4.7). In the results, users had to do the same as in the previous view, and the feedback was very similar, but "[emotions] individually are much easier to understand than the free drawing", one said, as he was "used to thinking of emotions separate from each other", getting higher scores (U:3.5; S:3.5; E:3.5).

In the last search, T 2.6, users had to *'search for the movie Back to the Future and proceed to its visualization'*. This was the quickest and easiest task because it is the usual way to search for something in most applications (U:4.8; S:4.7; E:4.9). The only suggestion was to include "an auto complete", something common in most applications, although not our focus in this work.

Movie Visualization. In T 3.1, users were asked to *'describe what they see in the Emotion Wheel visualization, namely the emotions that were felt; say if they were mostly more positive or negative, and more intense or calm'*, and finally, they were asked to *'choose an emotion and visualize the corresponding movie scene'* (U:3.6; S:3.5; E:3.2). In general, users completed the task in the expected time, only hesitating a bit when accessing the movie scene, as they were not familiar with the visualization and were not sure if they should click them; then finding this feature very interesting and useful.

In task 3.2, users were to *'identify the dominant emotion on the Emotion Wheel'*, and then to do the same, to compare, in the cumulative Dominant Emotions Wheel; where they found it easier to do. Here, they also had to *'identify which emotion was absent and which ones had the same level of occurrence'*. Overall opinion was quite positive (U:4.0; S:4.2; E:4.5), with some users considering the visualization visually appealing and easy to understand.

Back to the Emotion Wheel view, in task 3.1.1, users had to *'identify overlapping emotions (with similar VA felt more than once); which emotion was felt the longest; and which one was felt more often"*. The overlaps were well identified in a reasonable time, but some users did not find it obvious at first that they could interact with overlapping circles (that would change transparency level on hovering) to inspect these emotions; although the transparency hinted where the overlaps were. So, satisfaction and ease of use were scored below its usefulnessl (U:3.8; S :3.4; E:3.4). Still on this view, in task 3.1.2, the emotional path of the film is presented, or replayed, through an animation with lines forming between circles from the first emotion to the last. It was asked to *'watch and identify emotions in this path'*, which was quite easy paying attention to the animation, but not so easy at the end to know the direction time goes by, the first and last one. In general, they considered it a good feature (U:3.6; S:3.9; E:4.1), highlighting: "To Replay this animation is very helpful".

In task 3.3, the emotional path is represented using the metaphor of the X-Ray, and the users are asked *'which is the dominant emotion; the one felt for the longest time; and again which ones are the first and last emotion'*. This visualization did not please users so much (U:2.9; S :2.9; E:3.0), lacking the emotion colors and due to the confusion caused by the overlapping lines that are more visible here; they would prefer the circles only, that already have a color hinting the order (in grayscale, as they discovered), and the replay animation to show from the oldest to the most recent emotion. One user mentioned not liking this view for being so monochromatic; and interestingly, the radiologist doctor was the participant who understood and appreciated this view better; which has a purpose to temporarily highlight the emotional evolution along time, not to be used instead of the colored view. Like x-rays are not used instead of pictures, but to visualize otherwise hidden properties.

On the other hand, in task 3.4, the visualization using the metaphor of the Contrail of an airplane in the sky pleased the users much more (U:3.4; S:3.6; E:3.8). They found it "very interesting", "out of the box", "easier to understand", even if the colors are quite similar to the X-Ray, changing width, color and transparency of the lines along time (narrower and less transparent in the most recent emotions). The users were again asked to *'identify the dominant emotion; the one felt for the longest time; which ones are the first and last emotion, using replay if necessary*'; and some comments included: "I liked the color change along with the change in width"; "Pleasant viewing"; "Replay is a nice feature"; and suggesting that the older lines did not need to be so transparent to be better noticed.

In task 3.5, on the Emotion TimeWheel View, the emotional path or story of the film is presented with all emotions related to a timeline. The users were asked to *'identify the dominant emotion; which one was felt for the longest time; which one was felt more often; in which part of the film there was a greater concentration of the emotion joy; and which was the first and last emotion to be felt'*. Overall, this was considered by many "the best view to answer all the questions asked in the Movie Visualization task list", and especially the ones dealing with temporal aspects (U:4.4; S:4.1; E:4.0). Other comments included: "the best way to demonstrate the emotional path"; "aesthetic and very easy to understand". Suggestions: "The timeline could fill in automatically as we watch the movie"; "It could allow to go to the movie scenes at those times", which we already have in other features (Nunes et al., 2022) not evaluated here, synchronizing and indexing all the views with the movie being played.

Global Evaluation. Overall, users found the application and the evaluated features quite interesting, innovative and visually appealing. Although there were some difficulties at first in some of the most unusual visualizations, for the participants less familiar with this kind of representations, ease of use was also mentioned, and was even rated higher in the mean USE values of all the features. The global USE classification (U:3.7; S:3.9; E:3.8), rated in separate by the users, is close to the mean value calculated from the features' ratings (U:3.9; S:3.9; E:4.2), reflecting that in general users found it useful, easy, and quite satisfactory to use these interactive features; and had a good experience. When explicitly asked to refer to the features that they appreciated the most, they mentioned: the random movie display; the TimeWheel; the search by facial expressions using the camera (the one they mentioned the most), but also by emojis, word percentages, and by discrete points; the view of the dominant emotions; the contrail; and the connection of the circles to the scenes of the movie (alowing to navigate to the video scenes taking the emotions into account). For global suggestions, they repeated a couple that were already mentioned in the tasks, described above.

To summarize this appreciation, users classified the application with most relevant (as many as they found appropriate) perceived ergonomic (8 positive + 8 negative (opposite)), hedonic (7+7) and appeal (8+8) quality aspects in (Hassenzahl et al., 2000).

Interesting was the most chosen term. Comprehensible, Pleasant, Clear, Trustworthy Original and Innovative were also chosen by half or more subjects. Just one negative term was chosen:

Table 2: Quality terms users chose for As Movies Go By.

Terms	type	#	Terms	type	#
Interesting	E	10	Controllable	E	3
Comprehensible	H	8	Exciting	H	3
Pleasant	A	8	Exclusive	H	3
Clear	E	6	Impressive	H	3
Trustworthy	E	6	Aesthetic	A	3
Innovative	H	5	Attractive	A	3
Original	H	5	*Complex*	E	3
Good	A	4	Simple	E	2
Motivating	A	4	Inviting	A	2
Sympathetic	A	4	Desirable	A	2
Inviting	A	3	Familiar	A	1

H:Hedonic; E: Ergonomic; A: Appeal;
note that: Simple (+) vs *Complex (-)*

Complex (3 times), very close to the opposite positive term: Simple (2 times). Complex is also associated with being rich in terms of the features that are provided, and these were perceived as Comprehensible and Clear. The chosen terms are well distributed among the (H)edonic, (E)rgonomic and (A)ppeal qualities; with more H and E terms in the top positions, but more A terms overall. These results confirm and complement the feedback from the other evaluation aspects and user comments.

5 CONCLUSIONS AND PERSPECTIVES

The proposed interactive mechanisms to search and visualize movies based on dominant and emotional impact along the movie, with different models and modalities, extended previous features and addressed challenges and open issues in promising ways.

Most users found the application and the evaluated features quite interesting, comprehensible and pleasant, and also clear, trustworthy, innovative and original. The USE ratings reflected that in general users found the interactive features useful, easy, and quite satisfactory to use; in spite of the initial difficulties and lower scores in some of the most unusual visualizations. Different features excel in different situations, and some have a more supporting role than others; e.g. views to highlight emotions overlapping, or the order when they were felt, at the expense of the emotion color; suggest they could cohexist and be used with a purpose, in complement.

Other examples: the TimeWheel was considered the best view to deal with the temporal aspects, although it uses some space in the wheel that is important to represent the emotions (the Emotion Wheel being better for that); the search by facial

expressions using the camera was the most highlighted feature, for the modality and the automatic detection, but it is limited in the variety of expressions recognized (6 by Ekman at the moment), whereas emojis can represent a much larger set, and the users did also mention they would like to have more emotions; the X-Ray metaphor has an interesting potential, but was superseded by the Contrail that in a way extends the same concept with a stronger representation.

The pragmatism, clarity and beauty of the summarization in the dominant emotion view was also very much appreciated, the top for this purpose; and they enjoyed drawing trajectories with discrete points. They also liked the connection of the circles to the movie scenes, alowing to access them based on emotions, and to increase emotional awareness; and the replay feature, to animate the emotion visualizations and watch in a short time how the emotional impact evolved. Actually these two features exist in most views, but were tested once or twice in the context of other features, so they did not get and explicit score, that would for sure be quite high. Finally, from the start, users really enjoyed the random movie display as they enter the homepage, adding to the flavour of surprise and serendipity.

Future work includes refining, based on the evaluation and user feedback, and further extending the interactive visualization and search features, to provide useful and interesting ways to perceive and find movies that we value and can enrich our experience, increase our emotional awareness, and ability to even regulate our emotional states. Search based on current emotions using other sensors and VA can also be explored to suggest how to reinforce or balance into desired states. Recommendation techniques based on affective states and impact, preferences and access patterns can help in this direction (Tkalcic, 2011). Scale is also an important aspect to keep in mind, either in the amount of movies, and the amount of emotions detected or annotated in each movie; although filtering most relevant and e.g. listing by pages, highlighting top 3 emotions and aggregating dominant properties, can already help. Other media and modalities (Ramalho & Chambel, 2013; Serra et al., 2014) can also be explored for accessibility and to increase awareness even when not relying on the visual dimension, e.g. when listening to a talk or a song, or just focusing the visual attention on the movie, for a more immersive experience.

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