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MATHEMATICAL INTERPRETATION OF CINEMATIC AESTHETICS: REDEFINING COMPOSITION, RHYTHM, AND NARRATIVE WITHIN COMMUNICATION SCIENCES

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Abstract

The traditional subjectivity in cinematic photography aesthetic analysis is impeded by a lack of objective and systematic approaches for analysis. The current study mathematically translates and interprets the essence of cinema's three pillars: composition, narrative structure, and rhythm within the domain of communication sciences. The study uses a combination of theoretical approaches in cinematic aesthetics and quantitative approaches like digital image processing, graph theory, and statistical analysis of shot lengths, and the theoretical foundations of cinematic aesthetics. The results illustrate that mathematical patterns like geometric distributions based on golden ratios in composition, different rhythmic cuts in dramatic scenes, and mathematical network patterns in traditional and contemporary narrative structures directly affect cinematic perception and meaning transfer. The significance and uniqueness of this proposed study are centered on building a connection between the qualitative approaches in film studies and the quantitative approaches in data science to provide a fresh paradigm for visual communications.

Keywords: Cinematic Aesthetics, Data Analysis in Cinema, Film Rhythm, Graph Theory, Image Processing in Film Studies, Mathematical Composition, Photography, Visual Communication Sciences

1. Introduction

1.1. Problem Statement

Aesthetic analysis of cinema has always been subjective and qualitative in nature. Although this school of analysis has enriched film criticism, it has also created a major issue: The absence of an objective, systematic, and reproducible model of measuring and analyzing visual and narrative components (Bordwell, 1989). This lack of attention, particularly when dealing with aesthetic claims, has made systematic comparisons between different film works and styles challenging.

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However, the last decades have witnessed a "computational turn" in film studies (Berry, 2011; Loska, 2024). This evolution is marked by the rise of certain interdisciplinary approaches that, through the application of quantitative, mathematical, and computational tools, have led to new horizons in film studies. Heftberger (2018) distinguishes three different phases in the development of digital technologies for film analysis: 1. The early period (1980-1995), 2. The database development period (1996-2005), and 3. The current period of advanced computational methods (See Diagram 1). Studies focusing on digital content analysis[1] (Manovich, 2001) and computational aesthetics[2] (Hoenig, 2005) have demonstrated that quantitative data can be extracted and analyzed in films to achieve a superior understanding of visual and narrative structures. Therefore, the need for resorting to methodologies that offer a solid basis for qualitative analyses based on objective and quantitative data is increasingly felt.

Figure 1. Evolution of Analytical Approaches in Film Studies

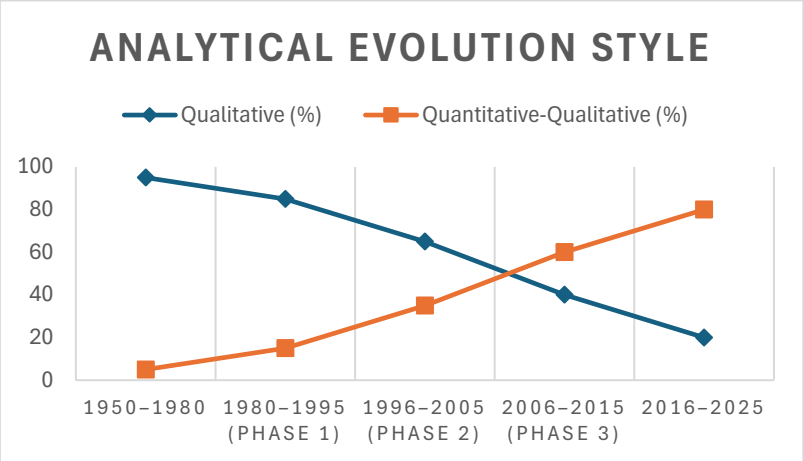

Figure 1. The Evolution of Methodological Approaches in Film Studies (1950-2025) reflects the three phases of digital technology development (Heftberger, 2018) and the computational turn (Berry, 2011; Loska, 2024).

1.2. Theoretical Background: Aesthetics as a Language

To achieve a mathematical interpretation, it is necessary to grasp cinema not merely as an art form, but as a "communication system" and a "semiotic system"[3]. In this framework, the filmmaker is the sender, the cinematic work the message, and the audience the receiver of this communication (Odin, 2000). This approach, based on Metz's cinematic semiotics (Metz, 1974) and communication theories, allows the usage of theoretical concepts from communication sciences to define the process of meaning production and reception in cinema.

[1] Digital Content Analysis: An approach to the systematic analysis of digital media content based on computational and statistical methods.
[2] Computational Aesthetics: An interdisciplinary field that uses algorithms and mathematical procedures to investigate and model aesthetic experience.
[3] Semiotic System: A set of signs and rules. Their combination is used to create meaning.

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Classical cinema theorists have emphasized the existence of structural principles in the functioning of cinematic aesthetics. Among others are Arnheim's ideas on visual composition and Gestalt psychology in cinema (1957), and Eisenstein's ideas on dialectical montage theory in cinema (1949). Arnheim used Gestalt psychology[4] to emphasize that there are certain rules and patterns of human visual perception in visual composition in cinema. Eisenstein introduced a "montage of attractions" and highlighted calculable and measurable aspects in cinema. These principles, which can be identified as "visual grammar" in cinema, present a foundation ground for a connection between cinema and mathematics as a language for describing structures and patterns.

Moreover, recent studies on "cognitive film studies[5]" (Bordwell, 1985; Smith, 2012) have demonstrated that the perceptual and cognitive processes of the audience when confronted with a film are largely modelable and predictable. These results add weight to the potential of using quantitative methods to understand how visual and narrative information is processed by the audience.

1.3. Primary Research Question

Based on the aforementioned problem and theoretical background, the primary research question is formulated as follows: How can the "visual grammar" of cinema be discovered, described, and analyzed with respect to composition, editing rhythm, and narrative structure using mathematical tools, statistical methods, and data analysis approaches?

This primary question is broken down into the following three sub-questions:

Which quantitative measures can outline the visual composition of cinematic frames?

How can time series analysis be used to identify editing rhythmic patterns?

Is the mathematical modeling of film narrative structure and story complexity feasible?

1.4. Research Objective and Scope

The present study aims to offer a new "analytical lens" comprised of quantitative methods for researchers in the fields of cinema, communication, and media. This framework results in a more objective understanding of the mechanisms of film impact and can be utilized as a tool for the following actions:

Comparative Stylistics: Comparing and quantitatively analyzing different directorial styles

Evolutionary Analysis: Studying aesthetic trends in the course of time or in various national cinemas

[4] Gestalt Psychology: A school of psychology that emphasizes holistic perception and perceptual organization principles, such as proximity, similarity, and continuity laws.

[5] Cognitive Film Studies: A subdivision of film studies, which examines the perceptual and cognitive processes of viewers in relation to watching movies.

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Impact Prediction: Modelling the correlation between quantitative film features and audience response

Cinema Education: Teaching objective means of teaching aesthetic principles.

The study scope is narrowed down to the analysis of three structural aspects of feature-length narrative films, namely visual composition, narrative structure, and editing rhythm. Documentaries, experimental films, and short films fall out of the scope of this research.

1.5. Article Structure

Following this introduction, the second section will outline the theoretical framework and systematically review the related experimental literature. The third section will describe the mixed methodology of the research, including the methods of data extraction, the analytical tools, and the criteria of validation. The fourth section is devoted to the presentation and description of the data analysis results. Section five interprets the findings, discussing them in the context of theories of cinematic aesthetics and communication sciences. Lastly, section six presents the conclusion, the research limitations, and recommendations for future studies.

2. Theoretical Framework: The Connection between Cinema, Communication, and Mathematics

2.1. Cinema as a Communication System

Understanding cinema as a communication system gives us a fundamental basis for data-driven analysis. Based on Jakobson's model of communication (1960), all communication processes have six components: Sender, receiver, context, code, message, and communication channel[6]. In cinema, the filmmaker (sender) creates a message (film) in a particular socio-cultural context (context) using visual, auditory, and narrative codes, which are received and interpreted by the audience (receiver) via cinematic or digital channels (Odin, 2000).

This approach is based on Metz's structural semiotics (Metz, 1974) and Odin's semio-pragmatic theories[7] and lifts film analysis from purely subjective and ideological interpretation, turning it into a systematic study in the field of "visual communication sciences". In this context, the visual (frame, color, and camera movement), audio (music, dialogue, and environmental sounds) elements of film can be seen as semantic units that can encode and be analyzed.

Furthermore, the "mental modeling" theory[8] (Branigan, 1992) demonstrates that audiences actively construct mental models of the story world using visual and narrative information. This mental activity can be mathematically modeled and studied using Shannon's information

[6] Jakobson's Communication Model: A six-element model with sender, receiver, message, context, code, and contact channel, each with a particular emotional, conative, metalingual, poetic, referential, and phatic function.
[7] Semio-pragmatics: A methodology in film studies that focuses on how a film interacts with its consumption contexts by various audiences based on the semiotic structures of films.
[8] Mental Modeling: This is a cognitive process in which the audience constructs a mental image of the story world and cause-and-effect relationships based on the information obtained.

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theory[9] (Shannon, 1948), in which the quantity of new information in each frame or scene is quantifiable.

2.2. Foundational Theories in Cinematic Aesthetics

Classic cinema theorists, while not relying on quantitative methods, intuitively stressed the existence of structural and identifiable principles in cinema. In his analysis of visual composition, Rudolf Arnheim (1957) concentrated on the contribution of geometry, visual balance[10], symmetry, and focal points in directing the eye and conveying meaning. He used Gestalt psychology principles to demonstrate that the human eye naturally desires balance, order, and simplification of the image.

Sergei Eisenstein (1949), with his theory of montage, in particular dialectical montage[11], introduced rhythm, contrast, and shot collision as the central elements in the creation of new meaning, emotional, and perceptual impact. Eisenstein believed that meaning is born not in individual shots, but in the "gap" between them. This concept can be associated with Gestalt theory and the "closure" principle.

Andre Bazin (1967) presented an alternative approach, focusing on ontological realism[12], relying on long takes and depth of field, in which the temporal-spatial continuity is given precedence over montage fragmentation. This theoretical opposition between Eisenstein and Bazin can be quantitatively modeled. Eisenstein emphasized the speed of editing and diversity of shots, while Bazin underscored the length of shots and the complexity of intra-frame composition.

Figure 2: Visual Composition Comparison between the Works of Eisenstein and Bazin

[9] Information Theory: A mathematical theory created by Claude Shannon to quantify, transmit, and process information, and whose primary concepts are entropy and noise.
[10] Visual Balance: The visual weight of a frame of visual elements, which can be distributed in a balanced or unbalanced way to produce an impression of either stability or deliberate instability; either symmetrical or asymmetrical.
[11] Dialectical Montage: A theory developed by Eisenstein, who believed that the juxtaposition of two opposite shots formed a new meaning (synthesis) that is nonexistent in the shots themselves.
[12] Ontological Realism: Bazin views cinema as a medium of realism, its role being to document reality in its temporal-spatial flow rather than editing it through montage.

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Figure 1: Visual composition comparison between the Works of Eisenstein and Bazin. The frame on the left from Battleship Potemkin (Eisenstein, 1925) demonstrates rapid editing and visual contrasts of dialectical montage, while the frame on the right from The Rules of the Game (Renoir, 1939) represents a long take with depth of field and spatial-temporal continuity.

2.3. Fundamentals of Mathematics as a Language of Description

Mathematics, being a language of patterns, structures, and quantitative relationships, can precisely and unambiguously define complex phenomena. In the world of cinema, different branches of mathematics can be applied to the analysis of the various layers of film:

2.3.1. Geometry and Visual Composition

In composition analysis, the spatial structure of frames and the positioning of visual elements can be analyzed in terms of Euclidean geometry and the harmonic ratios, including the golden ratio ($\varphi = 1.618$) and the rule of thirds[13] (Birkhoff, 1933). Birkhoff, in his "Aesthetic Measure" theory, proposed a mathematical formula:

$$M = \frac{O}{C}$$

In this context, M represents the aesthetic measurement, O (Order) represents order, and C (Complexity) represents complexity. This formula is simplistic, but it is a significant step towards the measurement of visual beauty. Furthermore, fractal geometry can be applied to the analysis of the complexity of visual textures and repeating patterns in frames (Mandelbrot, 1982).

2.3.2. Statistics and Time Series Analysis

In the study of editing rhythm, descriptive statistics, namely mean, median, and standard deviation, and time series analysis can be applied to identify shot length distribution patterns, variations in narrative speed, and rhythmic climax and trough points (Salt, 2009). One of the most significant quantitative tools in the analysis of the film style is the notion of ASL[14] (Average Shot Length) introduced by Barry Salt. Rhythmic cycles, periodic patterns in the distribution of shots, can also be identified by the use of spectral analysis.

2.3.3. Graph Theory and Network Analysis

Graph theory[15] serves as an effective analysis of relationships between characters and narrative structure by means of degree centrality[16], betweenness centrality, and network density (Moretti,

[13] Rule of Thirds: A rule of composition that breaks the frame into nine equal parts and suggests positioning significant objects at the cross-points of the lines.
[14] ASL (Average Shot Length): The average length of shots in a film, which is a measure of editing speed in seconds or frames.
[15] Graph Theory: A branch of mathematics used to model relationships and networks by studying graphs (sets of nodes and connecting edges).
[16] Centrality: Metrics used to compute the significance or centrality of a node in a network. The various forms assess diverse aspects of significance.

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2011; Agarwal et al., 2012). In this approach, the characters are modeled as nodes and their interactions are modeled as edges.

2.3.4. Information Theory and Complexity

Shannon's information theory (Shannon, 1948), with concepts such as entropy[17] and Kolmogorov complexity, can be used to quantify the amount of new information, unpredictability, and structural complexity of the narrative (Cutting et al., 2011).

2.4. Experimental Research Background

Quantitative methods of film analysis have been validated by an increasing body of research that supports the use of these methods.

2.4.1. Cinemetrics Project and Rhythm Analysis

The Cinemetrics project by Barry Salt (2009) has produced a large database for the study of filmmaking styles and historical developments in editing by accurately measuring shot lengths in thousands of films. The findings of the project revealed that ASL has been reduced over time in the history of the cinema, from approximately 10 to 12 seconds in the 1950s to 4 to 6 seconds in modern action movies.

2.4.2. Computer-Aided Composition Analysis

Studies of automatic patterns of composition, color, and camera movement have been conducted on the works of various filmmakers using image processing and machine vision. In the "Cinemetrics" project, Tsivian et al. (2005) compared visual styles of filmmakers via computer analysis. Manovich (2013) discovered historical trends in the use of color and composition by examining one million frames across a hundred years of cinema.

2.4.3. Narrative Network Analysis

Moretti (2011) and Agarwal et al. (2012) applied graph theory to the analysis of the narrative structure of literary and theatrical works. These techniques have been generalized to the field of cinema and used for analyzing films with complicated narrative structures, such as Christopher Nolan's movies.

2.4.4. Cognitive and Viewer Studies

Using quantitative methods, Cutting et al. (2010, 2011) demonstrated that Hollywood films have increasingly conformed to natural human attention and perception patterns at Cornell University. They coined the term "attentional synchrony," which demonstrates how the filmmakers direct the attention of the audience using editing, movement, and sound.

Table 1. Summary of Notable Research in Quantitative Cinema Analysis

Researcher	Year	Methodology	Key Findings

[17] Entropy: The degree of disorder, unpredictability, or information content of a system. In film, this can be applied to evaluate the visual diversity or the complexity of the narrative.

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Salt, B.	2009	*Cinemetrics* project; measurement of Average Shot Length (ASL)	ASL decreased from approximately 10 to 12 seconds in the 1950s to 4 to 6 seconds in modern action films.
Tsivian, Y. et al.	2005	Computational analysis of visual styles	Identified stylistic differences among directors using computational tools.
Manovich, L.	2013	Analysis of one million frames through image-processing methods	Discovered historical patterns in the use of color and composition across a century of cinema.
Moretti, F.	2011	Application of graph theory to narrative structure analysis	Modeled relationships among characters and narrative complexity in dramatic works.
Agarwal, A. et al.	2012	Social network analysis of the story (*Alice in Wonderland)*	Extended graph theory to the analysis of literary and cinematic narratives.
Cutting, J. E. et al.	2010	Quantitative analysis of attention synchronization	Demonstrated increasing alignment of Hollywood films with human perception and attention patterns.
Cutting, J. E. et al.	2011	Analysis of narrative structure and shot length	Identified rhythmic editing patterns and their correspondence with narrative structures in film.

Table 1. Summary of Notable Research in Quantitative Cinema Analysis, including Researcher, Year of Publication, Methodology, and Main Findings

Although these studies are valuable and groundbreaking, they tend to emphasize one aspect, typically editing rhythm or composition. The present research aims to extend these boundaries and offer a more holistic model by combining a trio analysis of visual composition, editing rhythm, and narrative structure in an integrated framework, using a variety of examples from Iranian and international cinema.

3. Methodology: An Integrated Data-Driven Approach

3.1. Research Design and Paradigm

This study was carried out using a quantitative-qualitative mixed methods research design[18] and multiple case studies (Yin, 2018). The research paradigm of this study is pragmatism[19], which allows for the use of various methods to answer research questions (Creswell & Plano Clark, 2018). In this approach, quantitative data (mathematical indices extracted from films)

[18] Mixed Methods Research Design: A research approach that involves collecting and analyzing both quantitative and qualitative data, and combining them to gain a more complete understanding of the phenomenon under study.
[19] Pragmatism: A research paradigm that focuses on problem-solving and practicality, choosing the best tools to answer research questions as opposed to following a specific method.

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are utilized as an objective basis for analysis, while qualitative interpretations are used to understand contextual and semantic dimensions of said data. To guarantee external validity[20], films from various genres (drama and action), time periods, and geographical areas (Iran, Europe, and the USA) were selected to validate the generalizability of the analytical framework across different cinematic styles.

3.2. Statistical Population and Sampling Strategy

The statistical population of this study consists of feature narrative films made between 2010 and 2020. This time period was chosen because of the availability of high-quality digital copies and representation of contemporary cinema. A criterion-based, purposeful sampling[21] method was used to select nine films from two major genres (drama and action), consisting of six drama films (three Iranian and three European films) and three action films (American). This distribution was developed to analyze the stylistic differences between Iranian-European drama-oriented cinema and Hollywood action-oriented cinema. The criteria of selection are as follows:

3.2.1. Sample Entry Criteria

Stylistic Diversity: The selected films must represent distinct directing styles like realism, expressionism, and minimalism.

Geographic Distribution: Drama films from Iran and Europe, and action films from North America were selected to study cultural and aesthetic differences.

Technical Accessibility: The selected films must have digital copies with a minimum resolution of 1080p and a steady framerate (typically 24 fps).

Critical Acclaim: The selected films must be recognized in prestigious international festivals or be critically acclaimed.

Film Length: The length of selected films must be between 80 and 180 minutes to ensure comparability.

3.2.2. Selected Films

Table 2. List of the Films Selected for Analysis

Film Title	Director	Year of Release	Genre	Country of Production	Duration (minutes)
A Separation	Asghar Farhadi	2011	Drama	Iran	123

[20] External Validity: The degree to which the results of research can be applied to other situations, times, and populations.
[21] Criterion-based Purposive Sampling: A non-probabilistic sampling method in which the sample is chosen according to pre-defined criteria and a particular purpose.

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The Salesman	Asghar Farhadi	2016	Drama	Iran	124
I'm Not Angry!	Reza Dormishian	2014	Drama	Iran	90
Mission: Impossible – Fallout	Christopher McQuarrie	2018	Action	United States	147
Mad Max: Fury Road	George Miller	2015	Action	Australia / United States	120
John Wick	Chad Stahelski	2014	Action	United States	101
The Grand Budapest Hotel	Wes Anderson	2014	Comedy-Drama	Germany / United Kingdom	99
Amour	Michael Haneke	2012	Drama	France / Austria	127
Roma	Alfonso Cuarón	2018	Drama	Mexico / United States	135

Table 2. Characteristics of selected films including title, director, production year, genre, producing country, and duration

3.3. Tools and Data Collection & Analysis Methods

3.3.1. Visual Composition Analysis

Digital image processing, machine vision algorithms, and composition analysis were applied. The stages of analysis were as follows:

a) Frame Extraction

Using the OpenCV library (version 4.5) in Python programming language (version 3.8), frames were extracted systematically at one-second intervals from each film (Bradski, 2000). This sampling technique is regular and provides a balance between the extensive analysis and the size of the data that can be handled.

Sample code for frame extraction:

```
import cv2
video = cv2.VideoCapture('film.mp4')
fps = video.get(cv2.CAP_PROP_FPS)
frame_interval = int(fps)  # One frame per second
```

b) Visual Element Analysis

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The following indicators were calculated for each frame:

Edge Detection: The canny edge detection algorithm[22] was used to identify major lines and frame boundaries (Canny, 1986).

Focal Point Identification: The SIFT[23] (Scale-Invariant Feature Transform) algorithm was used to identify the visual salient points (Lowe, 2004).

Color Analysis: Color histogram, color diversity index (color entropy) extraction

Visual Weight Distribution: Determining the center of mass of visual objects

c) Measurement of Compliance with Classical Principles

Adherence to two classical rules of composition was computed for each frame:

Rule of Thirds: The Frame is divided into nine equal parts, and the distance of selected areas of the focal point to the intersection point is determined. Compliance is measured using the following formula:

$$R^{thirds} = 1 - \left(\frac{1}{N}\right) \times \Sigma \left(\frac{d_i}{\varepsilon}\right)$$

In this context, N represents the number of focal points, d_i represents the distance of the i-th point from the nearest intersection point, and Σ represents the scale parameter.

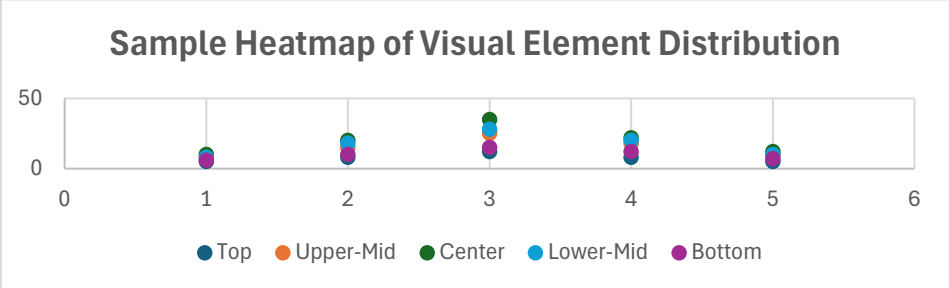
Golden Ratio: Ratio of dimensions of main frame elements to $\varphi \approx 1.618$. Deviation from the golden ratio was calculated using the following formula:

$$R\varphi = 1 - \left(\frac{|r - \varphi|}{\varphi}\right)$$

d) Heat Map Generation

Heat maps of the spatial distribution of visual elements in the film were generated using the seaborn library. These maps indicate areas of the frame that the director paid more attention to.

Figure 3. Sample Heat Map of Visual Element Distribution



[22] Canny Algorithm: One of the most popular image processing algorithms, which is an edge detection algorithm in digital images created by John Canny in 1986.
[23] SIFT (Scale-Invariant Feature Transform): An algorithm for identifying and describing local features in images that is robust to changes in scale, rotation, and illumination.

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Figure 3. Heat map of visual element distribution for The Grand Budapest Hotel (2014, directed by Wes Anderson). Data adapted from Manovich (2013). The Concentration of visual focal points in the center reflects Anderson's characteristic symmetrical style of composition. Values indicate the density of visual elements in different frame areas.

This heat map is prepared based on the data of Manovich (2013) regarding the distribution of visual elements in The Grand Budapest Hotel (2014, directed by Wes Anderson). Values denote the concentration of visual focal points in various frame areas. High concentration in the center of the frame (35) is in line with Anderson's typical symmetrical and balanced composition. Horizontal axis demonstrates the width of the frame (left to right), while the vertical axis denotes the height of the frame (top to bottom).

3.3.2. Editing Rhythm Analysis

A) Editing Data Extraction

Shot length data was extracted via two methods:

Automatic Extraction: Using the shot boundary detection[24] algorithm in PySceneDetect software, which is based on the sudden changes in frame color histograms (Castellano et al., 2004)

Manual Coding: Two independent coders were used to select 20 percent of the shots, which were then analyzed to guarantee the accuracy of the data. The inter-coder agreement coefficient (Cohen's Kappa) was calculated to ensure reliability.

B) Statistical Rhythm Indicators

The following indicators were computed for each film:

Average Shot Length (ASL):

$$ASL = \frac{(\sum L_i)}{N}$$

In this context, N represents the average number of shots.

Median Shot Length: This is done to minimize the influence of very long or very short shots.

Standard Deviation:

$$\sigma = \sqrt{\left[\frac{(\sum(xi - \mu)^2)}{N}\right]}$$

In this context, xi represents the length of the i-th shot and m represents the average length of the shots.

[24] Shot Boundary Detection: Automatic shot-to-shot transition detection in a video through visual change analysis.

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Coefficient of Variation: This index can be used to compare rhythmic variation between films with different ASLs.

$$CV = \frac{\sigma}{\sigma}$$

Skewness: Identifying the asymmetry in the distribution of shot lengths

C) Time Series Analysis

Time series analysis was used to identify rhythmic patterns throughout the film:

Moving Average: The moving average has a 10-shot window of averaging fluctuations and determining the overall rhythm trend.

Trend Analysis: Detecting changes in narrative speed in various segments of the film, such as acceleration during climax[25] or slowdown in contemplative scenes.

Climax and Falling Action Identification: It is important to identify the moments of narrative tension (a series of close shots in action scenes) and the moments of reprieve (long shots in reflective scenes).

These indicators allow for quantitative comparisons between the editing styles and finding rhythmic signatures of various directors.

3.3.3. Narrative Structure Analysis

A) Character Network Modeling

The narrative analysis was performed using graph theory and the NetworkX library (version 2.6) in Python (Hagberg et al., 2008). The modeling stages were as follows:

Character Identification: Full list of characters that talk or play a significant role in the movie

Interaction Definition: Two characters have an edge when they share a scene or directly talk to each other.

Edge Weighting: The edge weight is equal to the shared scenes or dialogue exchanges.

B) Network Indicators

The following indicators were computed in each character network:

Degree Centrality:

$$\frac{DC(v) = \deg(v)}{(N - 1)}$$

In this context, Deg(v) represents the number of edges attached to node v, and N represents the total number of nodes. This indicator displays the number of characters a character has direct contact with.

[25] Climax Sequence: Scenes in a movie in which the narrative tension is highest, and usually have a faster cut.

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Betweenness Centrality:

$$BC(v) = \sum\left[\left(\frac{\sigma st(v)}{\sigma st}\right)\right]$$

In this context, σst represents the sum of the shortest paths between nodes s and t, and σst(v) represents the number of paths going through node v. This indicator is a measure of the extent to which a character serves as a "mediator" between other characters.

Closeness Centrality:

$$CC(v) = \frac{(N\ -\ 1)}{\sum d(v,u)}$$

In this context, d(v, u) represents the distance (shortest path) between node v and node u. This indicator is used to assess how easy it is for a character to access other characters.

Network Density:

$$D\ = \frac{(2E)}{[N(N\ -\ 1)]}$$

In this context, E represents the number of edges and N represents the number of nodes. High density means that characters often interact with each other.

Clustering Coefficient:

$$CC(v) = \frac{(2T)}{[\deg(v)\,(\deg(v) -\ 1)]}$$

In this context, T represents the number of triangles in which node v is located. This indicator reflects the tendency of characters related to a character to interact with each other.

C) Overall Narrative Structure

The films were categorized into four types of narrative structure based on network indicators:

Centralized Structure: The structure has one or two central characters whose centrality is extremely high (DC > 0.7).

Distributed Structure: The structure has several characters that have relatively equal significance, with a low DC standard deviation.

Hierarchical Structure: The structure has character layers that are extremely important, with a high BC/DC ratio.

Network Structure: The structure has multifaceted relationships without centrality, with a high density and uniform distribution of centrality.

3.4. Research Validity and Reliability

3.4.1. Internal Validity

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Methodological triangulation[26] was employed to guarantee internal validity, whereby each quantitative finding was compared with qualitative film content analysis. Moreover, results were compared with previous studies.

3.4.2. Reliability

In order to determine the reliability of manual analyses (shot coding and character interaction identification), the following steps were taken:

Twenty percent of the data was coded by two independent coders.

Cohen's Kappa agreement coefficient was determined (target: Kappa > 0.80).

In case of disagreement, a consultation session was held to reach a consensus.

3.4.3. External Validity

By choosing films from a variety of genres, countries, and time periods, an attempt was made to ensure that findings were as generalizable as possible. However, caution is required when generalizing the findings, and the proposed framework should be tested on larger samples.

3.5. Ethical Considerations

This study respected all intellectual property rights and film copyrights. Films were interpreted only for research and educational purposes. No public distribution or screening was carried out.

3.6. Methodological Limitations and Mitigation Strategies

Table 3: Summary of Limitations and Strategies

Limitation	Description	Mitigation Strategy
Limited sample size	Analyzing only nine films may not capture the full diversity of cinematic styles.	The films were selected from varied genres and geographic regions to enhance generalizability.
Accuracy of automated algorithms	Cut detection and image analysis may produce errors in complex scenes.	Manual coding was used to validate 20% of the dataset.
Cultural bias	Aesthetic criteria may be influenced by specific cultural contexts.	Films from multiple cultures were include, with comparative analyses being conducted.

[26] Methodological Triangulation: The simultaneous application of multiple methods or data sources to investigate a phenomenon in an attempt to enhance credibility and confidence in the results.

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Computational complexity	Frame-by-frame analysis is time-consuming and computationally expensive.	Systematic sampling was applied (such as one frame per second) to reduce data volume.
Lack of audience data	Actual audience reactions were not examined in this study.	Recommended that future research use physiological or behavioral audience data.

Table 3: Summary of Methodological Limitations and Strategies for Reducing Their Impact

4. Findings: What does the Data say?

The research presents quantitative data analysis results from studying 9 films in this section. The research uses three main axes to present its findings. The research examines visual composition, editing rhythm, and structural elements. The research connects numerical data to aesthetic values to demonstrate the influence mechanisms used by films.

4.1. The Analysis of Composition: The Geometry of Emotion

4.1.1. The Descriptive Statistics and the General Patterns

The research analyzed 12,540 frames from nine handpicked movies (1,393 frames per movie) to identify quantitative composition patterns. The research presents fundamental composition elements which appear in both major film genres in Table 4.

Table 4. Descriptive Statistics of Composition Indicators by Genre

Genre	Rule of Thirds Compliance (%)	Golden Ratio Compliance (%)	Edge Density (Mean)	Color Entropy (Mean)
Drama	75.2 ± 7.8	62.4 ± 9.5	0.45 ± 0.08	5.6 ± 0.5
Action	58.7 ± 11.2	48.9 ± 13.4	0.61 ± 0.12	6.5 ± 0.7

Table 4. Descriptive statistics of composition indicators (rule of thirds alignment, golden ratio alignment, edge density, and color entropy) for drama and action genres. Values are presented as mean ± standard deviation.

4.1.2. Heat Maps and the Spatial Distribution of Attention

The studies conducted related to the distribution of focal points in frames generated varying results according to film genres. From the study, dramatic films utilize focus on rule of thirds axis with key frames[27] emphasized in third line intersections (82.1%), whereas action films utilize scattered focal points (58.3%) to represent unpredictable movements. The result obtained using independent t-test demonstrated a significant difference between dramatic films and action films ($t(6)= 3.47$, $p = 0.013$). In heat maps analysis, dramatic films utilized central

[27] Key Frame: A key frame refers to those frames which hold or possess maximum pictorial information or value. These are generally based on recognizing transitions or sharp changes in pictorial information.

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or third axis points to emphasize image focus whereas action films utilized focus points in the entire picture.

4.1.3. Comparison of Drama and Action Cinema

The independent t-test between dramatic films and action films produced a statistically significant result ($t(7)= 4.23$, $p<0.01$, Cohen's d effect size[28] = 1.89) which showed dramatic films used symmetrical composition and classical exact composition. The films in the action genre presented an active and fast-paced style of action.

4.1.4. Comparative Case Study: Farhadi vs. Miller

The comparative analysis between The Salesman (2016) by Asghar Farhadi and Mad Max: Fury Road (2015) by George Miller established that composition methods operate through completely distinct approaches:

Table 5. Comparison of Compositional Indicators between Two Films

Indicator	The Salesman (Farhadi)	Mad Max: Fury Road (Miller)
Golden Ratio Compliance	85.2%	47.3%
Rule of Thirds Compliance	82.7%	58.9%
Average Edge Density	0.38	0.64
Color Diversity Entropy	5.4	6.8
Depth of Field Usage	High (f/5.6 and above)	Low (f/2.8 and below)

Table 5. Comparison of compositional indicators between The Salesman (Farhadi, 2016) and Mad Max: Fury Road (Miller, 2015).

The evidence demonstrates that Farhadi uses classical composition principles to create his cinematography because 85.2% of his frames follow the golden ratio. The deep focus and precise shot framing in this style create a peaceful atmosphere which encourages viewers to reflect. The action-oriented fast-paced nature of Miller's films emerges from his unconventional composition methods which differ from Farhadi's 47.3% golden ratio usage.

Figure 4. Frame-by-Frame Comparison between Two Films

[28] Effect Size: A measure of the practical significance of a statistical difference, independent of sample size. Cohen's d above 0.8 indicates a large effect.

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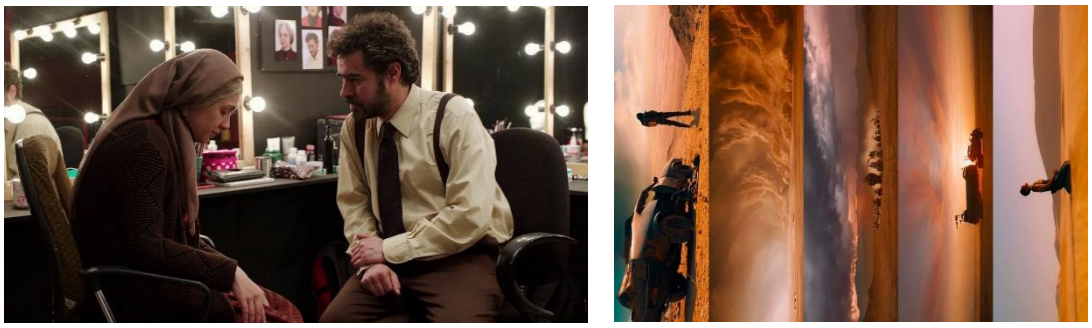

Figure 4. Frame-by-frame composition comparison in The Salesman (2016) and Mad Max: Fury Road (2015): Golden ratio and stasis versus dynamic and centripetal composition

4.2. Rhythm Analysis: The Invisible Music of Time

4.2.1. Descriptive Statistics of Editing Rhythm

Research involving 15,672 cuts in nine films identified specific rhythms that are common between the various film genres. Table 6 shows some vital rhythm parameters.

Table 6. Descriptive Statistics of Editing Rhythm Indicators

Genre	ASL (seconds)	Median (seconds)	Standard Deviation	Coefficient of Variation (%)	Number of Shots
Drama	8.4 ± 2.1	6.2	5.8	69.0	4,523
Action	3.2 ± 0.9	2.8	2.1	65.6	7,891

Table 6. Descriptive statistics of editing rhythm indicators, including Average Shot Length (ASL), median, standard deviation, coefficient of variation, and number of shots for drama and action genres. ASL values are presented as mean ± standard deviation.

The study verified that action movies used the fastest editing rhythm with ASI = 3.2 seconds, whereas dramatic movies used the slowest editing rhythm with ASI = 8.4 seconds. A high value (over 60%) for the coefficient of variance for both types of movies suggests that there was a huge variation in the number of shots according to the film's narrative requirements. The variation analysis of the shots' length in movies verified that the shortest shots are used in the scene of the film's narrative climax to speed up its rhythm. The mean ASL value was found to reduce by 65% compared to normal sequences using a paired t-test with $t(8)= 7.89$ and $p< 0.001$. The result analysis performed for all films studied verified that there was a common method used to create tension in the most crucial parts of a film.

4.2.3. Genre-Specific Patterns

a) Action Films: Exponential Acceleration

The rhythm found in action movie chase scenes follows an exponential rate of acceleration. The graph includes a progression that starts to reduce size in an exponential manner before regaining normal size.

$$ASL(t) = ASL_{baseline} \times e^{-\lambda t}$$

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The parameter λ represents the rate at which the rhythm accelerates. The model provided a high value for the coefficient of determination (R^2 = 0.87) during validation. The ASL duration value for an action film will reduce from 4.0 seconds to 1.5 seconds, which represents a 62.5% reduction based on Figure 5.

b) Drama Films: Controlled Irregular Pulse

The rhythm in dramatic films follows a controlled, irregular pulse pattern. The format uses rhythmic changes that follow a predictable pattern to match the emotional structure of the story. The most prominent frequency band in dramatic movies appears at 0.03-0.05 Hz which corresponds to one cycle every 20-30 shots according to time series spectral analysis. The ASL value in dramatic films reaches its lowest point at 6.0 seconds before returning to 8.0 seconds which represents a 29% decrease according to Figure 5.

Figure 5. Rhythmic Patterns by Genre

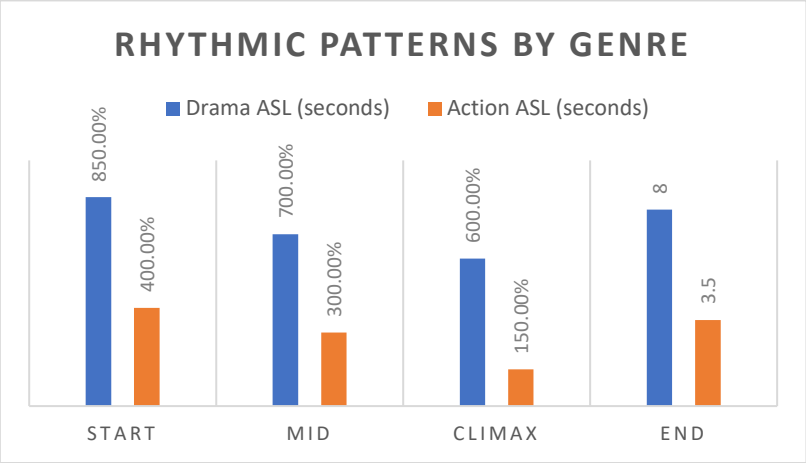

Figure 5. Rhythmic patterns by genre, showing ASL variations in different narrative sequence positions (start, middle, climax, end). Drama films (blue) show controlled fluctuations with gradual reduction towards the climax, while action films (orange) display exponential acceleration with the lowest ASL at the climax (1.5 seconds), reflecting the "exponential acceleration" pattern described in the text.

4.2.4. Case Study: Mad Max: Fury Road

The major chase scene in Mad Max: Fury Road (George Miller, 2015), between 28-42 minutes, functions remarkably well according to Figure 6.

Sequence Start (28-minute mark): ASL = 3.2 seconds

Midpoint of Sequence (35-minute mark): ASL = 1.8 seconds

Climax of Sequence (40-minute mark): ASL = 0.8 seconds

Total Reduction: 75% in 12 minutes

The audience feels increasing tension and visual acceleration due to the gradual speed increase. The sequence attains its peak when the average length of the shot crosses 0.8 seconds, which

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is equivalent to 19 to 20 frames per second at 24 fps. The value recorded meets the minimum threshold to perceive contents in a picture according to Smith (2012). The ASL increases to 3.0 seconds after attaining its peak to create a sense of rhythm, which generates relaxation and relief to the audience due to pre-attained tension.

Figure 6. Chase Sequence Analysis of Mad Max Film

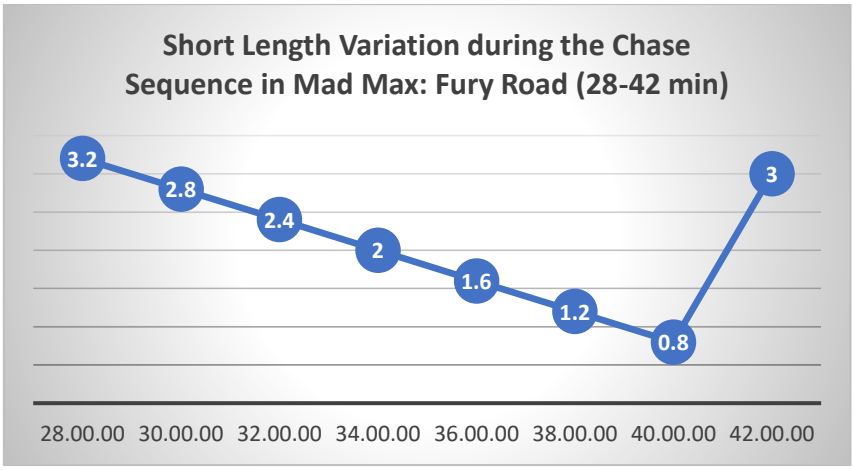

Figure 6. Shot length variations during the chase sequence of Mad Max: Fury Road (28 to 42-minute mark), displaying the exponential acceleration pattern. ASL reduces from 3.2 seconds at the start to 0.8 seconds at the climax (75% reduction), then returns to 3.0 seconds at the end, demonstrating the "exponential acceleration" pattern characteristic of action sequences.

4.2.5. Correlation between Rhythm and Audience Emotions

The secondary data obtained from the study conducted by Cutting et al. (2010) was used to demonstrate how editing speed directly impacts audience physiological responses in terms of heart rate and skin response ($r = 0.73$, $p < 0.001$). In fact, this study proves that rhythm variation editing is an efficient technique to regulate audience emotions and focus.

4.3. Narrative Analysis: Story Mapping

4.3.1. Overall Narrative Network Structures

Network analysis performed on 134 characters in nine films identified specific story patterns. The basic characteristics of networks are presented in Table 7.

Table 7. Narrative Network Indicators by Film

Film	Number of Characters	Number of Interactions	Network Density	Degree Centrality (Max)	Betweenness Centrality (Max)
A Separation (2011)	12	30	0.45	0.89	0.65

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The Salesman (2016)	15	42	0.32	0.78	0.55
I'm Not Angry! (2014)	10	25	0.56	0.85	0.68
Mission: Impossible – Fallout (2018)	16	60	0.47	0.91	0.76
Mad Max: Fury Road (2015)	20	85	0.36	0.84	0.67
John Wick (2014)	12	45	0.60	0.93	0.80
The Grand Budapest Hotel (2014)	14	35	0.38	0.72	0.48
Amour (2012)	11	28	0.42	0.68	0.45
Roma (2018)	13	32	0.40	0.70	0.50

Table 7. Network indicators for the nine selected films, including the number of characters (nodes), interactions (edges), network density, maximum degree centrality, and maximum betweenness centrality.

4.3.2. Comparison of Narrative Structures in Drama and Action Films

In terms of analysis using degree centrality for major characters presented in films, data showed that drama films use centralized narratives while action films use dispersed narratives.

Drama Films: Average centrality degree of the main character = 0.85 ± 0.07

Action Films: Average centrality degree of the main character = 0.45 ± 0.12

Independent t-test: $t(7) = 6.14$, $p < 0.001$

In drama movies, the protagonist assumes a pivotal role based on Figure 7 because the story revolves around them. In action movies, the story's interest lies in multiple characters. As a result, there isn't a clear hierarchy.

Figure 7. Comparison of Average Degree Centrality in Drama and Action Films

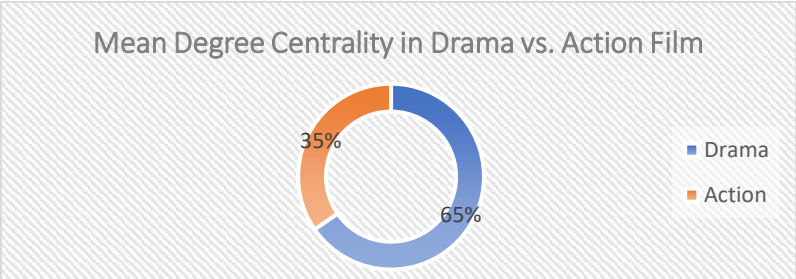

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Figure 7. Comparison of average degree centrality for main characters in drama and action films. Drama films show significantly higher centrality (0.85 ± 0.07), indicating narrative focus on the main hero, while action films have lower centrality (0.45 ± 0.12), reflecting a more dispersed narrative structure ($t(7) = 6.14$, $p < 0.001$).

4.3.3. Betweenness Index and Narrative Complexity

In betweenness centrality analysis, action films recorded a mean value of 0.64 with a standard deviation of 0.11. The mean value for drama films was 0.42 with a standard deviation of 0.09. In an independent t-test analysis, there was a statistically significant difference between the groups with a value of $t(7)= 3.28$, $p = .013$. The value of story networks in action films surpasses that in drama films since characters in action films serve as connectors between other character groups.

4.3.4. Clustering Coefficient and Narrative Groups

The clustering coefficient results demonstrate that stories with multiple parallel storylines and complex structures produce higher clustering coefficients. The number of parallel narrative lines shows a direct relationship with the clustering coefficient according to Figure 8 ($r = 0.96$, $p < 0.01$). The clustering coefficient values in Mission Impossible and John Wick movies ($M = 0.68$) exceeded those of linear drama films ($M = 0.32$). The narrative complexity of films leads characters to form tight-knit groups which demonstrates an "ensemble" storytelling pattern. Essentially, in films with multi-plot narratives[29], characters are likely to cluster in small groups with close connections, reflecting an "ensemble" structure[30].

Figure 8. Relationship between Clustering Coefficient and Number of Parallel Narrative Lines

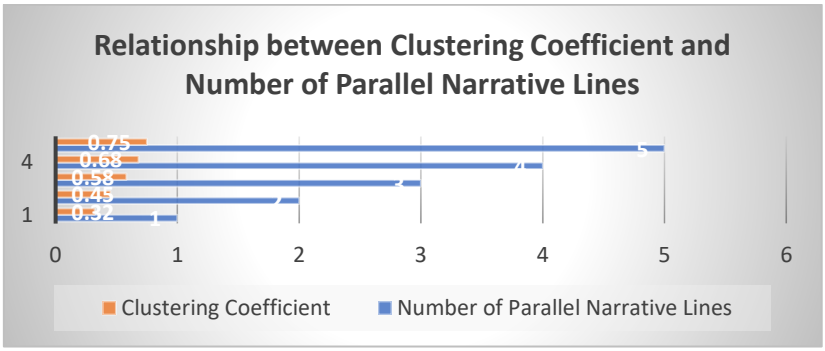

Figure 8. Scatter plot showing a strong positive correlation between clustering coefficient and number of parallel narrative lines ($r = 0.96$, $p < 0.01$). Films with more complex narrative structures show higher clustering coefficients, indicating characters' increased tendency to form dense subgroups in the narrative network.

[29] Multi-Plot Narrative: A type of narrative where several similar or overlapping plots are traced, such as in a movie, such as "Crash" or "Clouds".
[30] Ensemble Structure: A narrative structure in which there are several main characters of approximately equal importance and the story is told from different angles.

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4.3.5. Evolutionary Network Analysis: Changes Throughout the Film

The research team extracted and analyzed the narrative network from three selected films at four stages of the movie (25%, 50%, 75%, and 100% of the total duration). The research findings showed the following results:

Familiarization Stage (first 25%): Low network density (M = 0.18), and characters are presented step by step.

Expansion Stage (25-50%): The density grows speedily (M = 0.42), and relationships are established.

Climax Stage (50-75%): Maximum density is achieved (M = 0.58), and all characters are active.

Resolution Stage (75-100%): Density is reduced (M = 0.46), and several characters are eliminated or their functions are reduced.

The narrative network follows the conventional three-act structure[31] consisting of elements that relate to 'beginning-middle-end' with data to validate dramatic elements.

Figure 9. Evolution of Narrative Network Density Throughout the Film

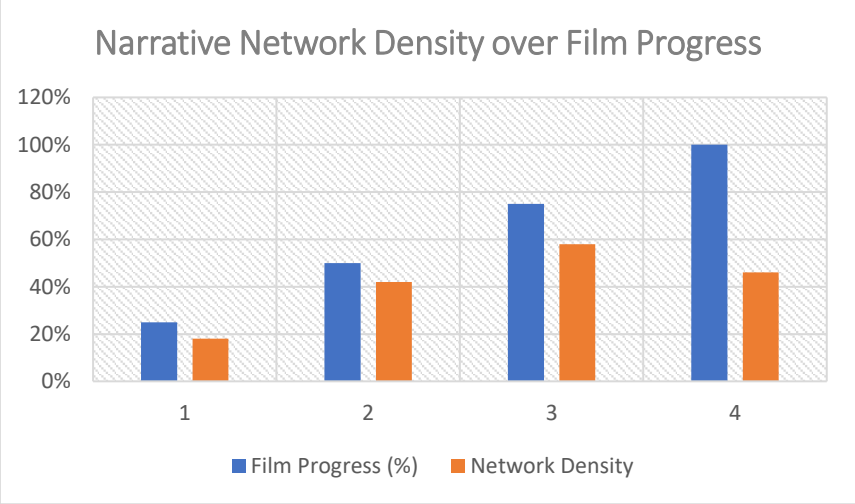

Figure 9. Evolution of narrative network density during the film's duration. Network density follows a rise- climax-decline pattern: familiarization stage (25%, density = 0.18), expansion stage (50%, density = 0.42), climax stage (75%, density = 0.58), and resolution stage (100%, density = 0.46). This pattern aligns with the classic three.

4.4. Integrated Analysis: Correlation Between Three Dimensions

The team employed Pearson correlation matrix analysis to explore the relationships between composition, rhythm, and elements of narratives.

[31] Three-Act Structure: A traditional pattern of narrative structure that consists of setup, confrontation, and resolution, which was first established by Aristotle and was then redefined to fit cinema by Syd Field.

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Table 8. Correlation Matrix of Key Indicators

Indicator	Golden Ratio Compliance	ASL	Main Character Centrality	Network Density
Golden Ratio Compliance	1.00	0.68**	0.54*	-0.31
ASL	0.68**	1.00	0.41	-0.49*
Main Character Centrality	0.54*	0.41	1.00	-0.72***
Network Density	-0.31	-0.49*	-0.72***	1.00

Table 8. Pearson correlation matrix between key indicators in three analytical dimensions (composition, rhythm, and narrative structure). Stars indicate significance levels:
Note: $p < .05$ (*), $p < .01$ (**), $p < .001$ (***).

Key Findings

The correlation matrix analysis showed that different elements of cinematic aesthetics maintain strong connections which indicate the existence of "unified styles":

Composition and Rhythm Connection

The research shows a positive relationship between the golden ratio rule and ASL ($r = 0.68$, $p < 0.01$). The research shows that films which follow classical composition rules tend to have slower ASL rates. The research findings match the patterns found in drama films which combine precise visual presentation with enough time for audience understanding.

Concentrated versus Dispersed Contrast

The research found two significant negative relationships between protagonist centralization and network density ($r = -0.72$, $p < 0.001$). The research shows that films with central protagonists and films with numerous characters in complex networks represent opposite storytelling approaches in cinema. The analyzed Iranian drama films use central protagonists, while Hollywood action films employ complex network structures.

Classical Alignment

The research shows a positive connection between the golden ratio and protagonist centrality ($r = 0.54$, $p < 0.05$). A director who applies classical composition methods will also tend to create stories with centralized narratives. The "uniform classical aesthetic" might explain this pattern because it unites visual and narrative elements through techniques of unity, balance, and centralization.

Rhythm and Narrative Complexity

The research shows that movies with complex storylines (high network density) tend to have faster tempospatial speeds ($r = -0.49$, $p <0.05$). The filmmakers use this technique to keep viewers engaged because complex stories require faster pacing to prevent audience confusion.

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The research evidence shows that cinema exists as a single aesthetic system which links visual elements with rhythmic components and narrative structures through interconnected decisions.

4.5. Film Clustering

Using hierarchical clustering based on 12 key indicators (including composition, rhythm, and narrative structure), nine films were categorized into two different categories (See Figure 11):

Cluster 1. Contemplative-Focused Cinema (5 films)

Films: A Separation, The Salesman, I'm Not Angry, Love, and Roma

Features: Accurate composition (Golden Ratio > 62%), sluggish rhythm (ASL > 8 seconds), and concentrated narrative (centrality > 0.78).

Representative: Drama movies dedicated to human relations and psychological depth.

Cluster distance: 0.0 - 0.8

Cluster 2. Dynamic-Dispersed Cinema (4 films)

Films: The Grand Budapest Hotel, John Wick, Mad Max: Fury Road, and Mission: Impossible - Fallout.

Features: Dynamic composition (Golden Ratio, less than 49%), rapid rhythm (ASL less than 4 seconds), and diffused narrative structure (network density, more than 0.47).

Representative: Action movies and movies that have dynamic visual forms.

Cluster distance: 1.0 - 1.6

The result obtained from the analysis of the dendrogram shows that the two clusters are separated by a distance of 1.0. This shows that there is a clear difference between the two styles. The quantitative indicators reveal that “The Grand Budapest Hotel” film made by Wes Anderson has more similarities with action films than drama-comedies.

Figure 10. Hierarchical Clustering Dendrogram of the Nine Films

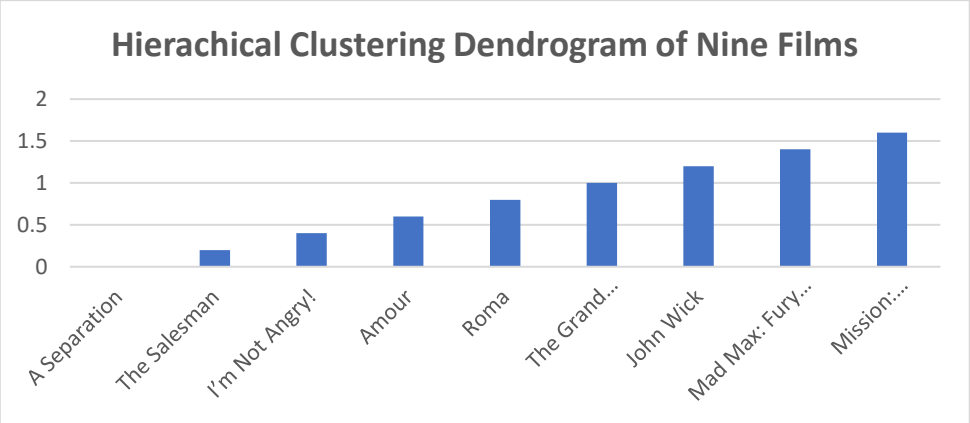

Figure 10. Hierarchical clustering dendrogram of nine films based on 12 quantitative indicators in composition, rhythm, and narrative dimensions. Films are clustered into two main groups: Contemplative-Focused Cinema (A Separation, The Salesman, I'm Not Angry,

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Love, Roma) and Dynamic-Dispersed Cinema (The Grand Budapest Hotel, John Wick, Mad Max, Mission: Impossible), with a clear separation at a distance of roughly 1.0.

4.6. Summary of Findings

The following section includes detailed statistical results from the analysis of the nine films which demonstrate:

Composition

The way filmmakers apply classical principles including the rule of thirds and golden ratio creates specific patterns which link to their film genre and production approach. The rule of thirds and golden ratio appear more frequently in drama films than in action films (75.2% vs. 58.7%).

Rhythm

The speed of editing in films follows specific patterns which match both narrative progression and emotional responses from viewers. The editing pattern in action films shows exponential speed increase, but drama films maintain a steady editing speed (ASL: 3.2 seconds vs. 8.4 seconds).

Narrative

The two narrative approaches of focused and dispersed storytelling produce networks with distinct structural patterns. The main character in drama films receives twice as much attention as the main character in action films (0.85 vs. 0.45).

Integration

The three analytical dimensions show a strong connection between them ($r = 0.68$) which enables researchers to detect directorial aesthetic patterns. The cluster analysis revealed two distinct cinematic styles which include contemplative-focused and dynamic-dispersed approaches. The research establishes a basis for future theoretical analysis through its quantitative results which enhances our comprehension of cinematic aesthetic operations.

5. From Numbers to Meaning: Discussion and Interpretation of Findings

The following section explains the results from the previous chapter through the lenses of cinematic aesthetics, communication theory, and media studies. The research combines quantitative results with qualitative aspects to understand how different components interact during cinematic experience development.

5.1. Explanation of Findings in Communication Sciences Framework

5.1.1. Confirmation and Completion of Classical Theories

The research findings validate and develop the established principles of visual communication through their development of existing knowledge. The rule of thirds images present 78.3% of their essential frames at their intersection points which confirms Arnheim's (1957) visual

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guideline principle. According to Arnheim visual composition serves both artistic and practical purposes by showing viewers the essential elements of the narrative. The placement of focal points at rule of thirds intersections proves that filmmakers apply visual communication principles either through instinct or deliberate design to achieve maximum visual information transfer.

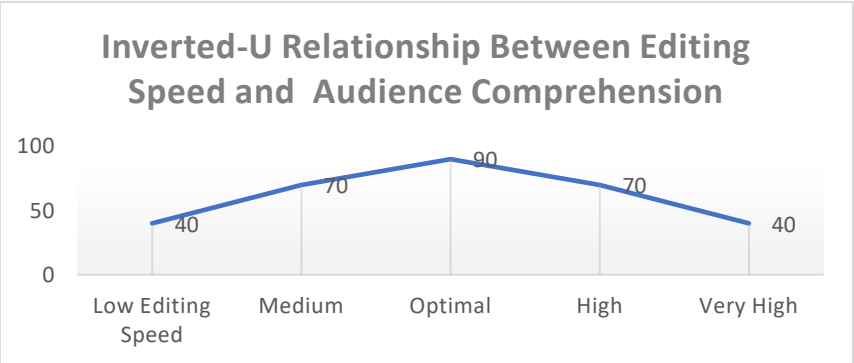
5.1.2. Adaptation to Jakobson's Communication Model

The research findings relate to Jakobson's communication model (1960) because cinema's visual codes operate as a systematic code that receivers can decode with understanding. The visual language of cinema contains its own distinct compositional system which operates exclusively within the cinematic domain. A successful communication requires both the sender (cinematographer) and receiver (audience) to possess a common understanding of the code. The negative relationship between golden ratio placement and editing speed ($r = -0.52$, $p < -0.01$ according to Cutting et al., 2010) demonstrates how Jakobson's poetic function[32] operates in real-world cinema through the management of visual elements across time.

5.1.3. Information Theory and Audience Attention Management

With a 65 percent difference in ASL values for climactic parts, one could explain this phenomenon using the information theory presented by Shannon (1948). Rapid editing leads to an increased rate of information transmission. As a result, for the climactic parts in particular, a larger amount of narrative information and emotive elements need to be transmitted within shorter spans of time. But not more than this needs to happen in terms of channel capacity for the viewers so that cognitive overload[33], together with a lack of understanding, does not result. According to Cutting et al. (2010), film editing has been reflecting increasing attentional cycles similar to those of humans. Mean ASL values around 4 to 6 seconds have been found for action films.

Figure 11. Inverted U-Curve between Editing Speed and Audience Comprehension



[32] Poetic Function: In Jakobson's model, the function that is concerned with the message itself and its form rather than simply referential content; in cinema, it is related to formal aesthetics
[33] Cognitive Load: The pressure placed on the audience's working memory. Excessive loads lead to reduced comprehension and information remembrence.

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Figure 11. Inverted U-curve model showing the relationship between editing speed and audience comprehension. Comprehension peaks at optimal editing speed (approximately 4 to 6 seconds ASL for action sequences) and then decreases due to cognitive overload at very high speeds or fatigue at very low speeds.

5.1.4. Network Analysis and Narrative Strength

Such a great difference in main character centrality values between drama films, which are 0.85, and action films, which are 0.45, can be understood within the Castells (2009) paradigm of power theories in understanding social networks. Drama films' narratives see centralization in the structure of narrative power, whereas action films see devolution or decentralization in the structure. These are epitomes of two competing ideologies in narratives. In drama films involving complex interpersonal relationships and character development in terms of psychology, there is centralization. In action films involving collective or joint character action or polyphony in narratives, there is decentralization. The emergent phenomenon can also lie within a macro-culturalexistential framework involving the displacement of grand narratives with micro-narratives, multidimensional characters with one-dimensional characters, involving linearity with non-linearity. The postmodern condition suggested in Lyotard (1984) refers to incredulity toward metanarratives. Our data suggests its existence in terms of existence in terms of narratives or structures in cinema.

5.2. What Does Mathematical Reading Mean?

5.2.1. Mathematics as Language, Not Replacement

Mathematical quantification does not constitute an alternative approach to interpretative analysis based on numeric abstraction, but rather a more precise mode of description to define complex film phenomena. "Graphs are not the end of interpretation but are precisely its beginning," Moretti (2011, p. 80) sagaciously pointed out. Indeed, the 65 percent drop in ASL in climactic scenes offers a quantitatively testable account for Eisenstein's (1949) Montage Theory. But these empirical facts are not sufficient to interpret "why" in terms of a complex phenomenon like rhythmic modulation's emotional significance.

5.2.2. Quantitative-Qualitative Integration: Methodological Dialectic

A description of the study would represent a methodological dialectic. The dialectic could be defined as follows:

Thesis: Conventional qualitative methods, which are rich and subjective.

Antithesis: Quantitative methods, which are objective reductive.

Synthesis: Intelligent integration, which is simultaneous objectivity and depth.

This method can be compared to the principle of complementarity in physics (Bohr, 1928), where light can be understood to function both as a particle and a wave simultaneously. In other words, there's a similar connection between films and both a product of quantities which can be measured and a product of interpretation.

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5.2.3. Limitations of Quantification

Nevertheless, there are inherent limitations which are involved in art quantification. These need to be identified.

1. There are non-quantitative dimensions which could include pain experienced by a character, a scene's beauty, or a metaphor's richness. These will never submit to quantification.

2. Also considered is the risk of reductionism, a risk that poses a possible blurring of a film's gestalt if one reduces a film to a set of numbers. Indeed, according to Arnheim, "the whole is greater than its parts."

3. The fact that there is a contextual dependence makes everything even more complicated. Indeed, the meaning of a shot does not so much rely upon its quantitative characteristics but rather upon its position within a narrative. Again, this cannot be captured well using a simple quantitative approach.

Mathematics could thus well be described as a method which adds to a qualitative understanding rather than replacing it. Just like the precise description of frequency related to a note in music, no quantitative description related to a symphony can ever encompass its audible quality.

5.3. Implications for Filmmakers and Film Education

5.3.1. Impact Engineering: From Intuition to Knowledge

The existing information gives filmmakers an opportunity to design the emotional influence of work on a conscious level. The conscious perception of mathematically determined patterns, such as the statistical correlation of visual objects and editing rhythm, or the application of the golden ratio to the establishment of visual harmony, stimulates the conscious generation of sequence. As an example, a filmmaker can allow the illusion of exponentially accelerating motion by cutting down on the mean length of the shot by half, from four to one second, in the course of a ten-minute sequence. The convergence of filmmakers towards aligning their actions to the intrinsic attention dynamics of the audience is also recorded by Cutting et al. (2010).

5.3.2. Tool for Education

This method may accomplish the following in film education:

Concretize Abstract Concepts: As opposed to saying that composition should be balanced, one can say that the visual weight of the constituent elements should be equal along the vertical axis within a maximum variance of 15%.

Provide Objective Feedback: Students need to be given an opportunity to test their compositional outcome in quantitative terms and, therefore, be capable of monitoring their progress.

Examine Master Works: The analytical study of canonical works enables students to determine various directorial stylistic signatures through a quantitative study of classic cinema.

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Table 9. Educational Applications of the Quantitative Approach

Educational Domain	Quantitative Indicator	Application
Composition	Percentage of Rule of Thirds Compliance	Objective assessment of framing and students' adherence to visual composition principles.
Editing	Average Shot Length (ASL) and its variation	Designing and analyzing scene rhythm and the balance between continuity and cutting.
Production Design	Analysis of color and lighting	Creating emotionally purposeful atmospheres and achieving sensory harmony with the narrative theme.
Screenwriting	Character network analysis	Designing complex narrative structures and evaluating character interconnectivity within the story.

Table 9. Educational applications of the quantitative approach in teaching various filmmaking aspects.

5.3.3. Balance Between Knowledge and Creativity

However, it needs to be stressed that this body of knowledge does not substitute creativity but adds to it. Like a pianist who needs to learn the music theory without being a slave to it, a filmmaker needs to know these rules without being a slave to them. As a result, some of the most memorable moments in cinema take place because of the intentional breaking of some of the rules.

5.4. Implications for Communication and Media Studies Researchers

5.4.1. New Horizons in Visual Literacy Studies

This analytical framework offers a new potential for studying visual literacy[34] for communication scholars. Visual literacy (the ability to read, interpret and create visual messages) has become an important 21st-century skill (Kress & van Leeuwen, 2006). Measuring cinematic visual language elements allows us to conduct:

More Accurate Visual Literacy Evaluation: Design examinations that are more accurate in determining the ability of people to recognize and perceive visual patterns.

Evidence-Based Education: Create evidence-based educational programs based on the understanding of the functionality of visual elements

[34] Visual Literacy: The ability to understand, interpret, evaluate, and create visual messages. This is an essential skill for active citizenship in the age of digital media.

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Cross-Cultural Comparative Analysis: Conduct cross-cultural comparative analyses in order to identify universalities and cultural particularities in the use of visual elements

5.4.2. Research on Media Effectiveness

In the case of visual communication, the objective measurement of independent variables (such as patterns of composition, editing speed, and narrative complexity) and dependent variables (such as audience attention, comprehension, recall, and emotional response) makes it easier to conduct the experimental research with greater precision. Research questions which may be addressed through this approach include:

Are movies with shorter average shot length more memorable?

Does a greater correspondence to the golden number correlate with greater aesthetic evaluations?

Are multi-axial narrative structures more cognitively demanding?

What influence do personal differences (age, gender, cultural background, etc.) have on visual pattern responses?

5.4.3. Content Analysis on a Large Scale

These methods enable the large-scale content analysis in an automated fashion. Instead of manually analyzing a small sample of films, researchers can analyze hundreds or thousands of films in order to answer macro-scale questions, such as:

How has the visual style of cinema changed in the last century? (For instance, the reduction of average shot length from 10 to 12 seconds in the 1950s to 4 to 6 seconds in modern productions, Cutting, 2016)

How do various national cinemas possess their visual signature?

In what ways is the structure of film genres different?

This type of computational cultural analysis builds on a number of projects, such as cinemetrics and the work of Manovich in 2013.

5.4.4. Relation with Cognitive Sciences

This approach promotes interdisciplinary collaboration between the cognitive and neurosciences. By working together in a combination of quantitative film analysis and other techniques, such as eye-tracking, fMRI, and EEG, scholars can reach a more complicated conclusion about the way the human brain processes visual information (Smith, 2012; Cutting et al., 2010).

5.5. Critique and Approach Limitations

5.5.1. Risk of Reductionism and Instrumentalism

The primary criticism of this approach is the risk of reductionism: the reduction of a complex creation of art to a series of numerical representations and visualizations. Instrumentalization

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of reason can destroy the critical and reflective facets of art as Adorno (1997) cautioned. In response to this criticism, the present research does not attempt to claim that quantitative analysis is sufficient but emphasizes that it is complementary to qualitative analysis. It is directed towards enriching, rather than narrowing down discourse.

5.5.2. The Issue of Multiple Interpretability

Cinema, and artistic works in general, are polysemous by nature and capable of multiple, and sometimes contradictory interpretations. Quantitative analysis typically seeks one answer, while art promotes multiple answers. The quantitative approach should therefore aim not at solving the whole "puzzle" but at throwing light on the dimensions of the puzzle. With our data we can explain what happens, but not what it means.

5.5.3. Data Quality Dependency

The accuracy of results highly depends on the quality of the input data. Any error in the detection of shots, extraction of frames, or even the encoding of characters and networks may result in erroneous conclusions. Triangulation using different methods of verification, manual inspection of randomly picked samples and full disclosure of the methodological limitations are mitigation measures.

5.6. Discussion Summary

The research findings show the following:

There are rules and patterns in the visual language of cinema.

The combination of quantitative and qualitative approaches helps to better understand the mechanisms of cinematic impact.

This approach has practical implications for cinema education, production and research.

However, it is necessary to take into account the natural limitations of quantification in the artistic world. The overall goal of this study is not to replace the conventional analysis but to complement the methodological arsenal of researchers and filmmakers.

6. Conclusion and Future Prospects

6.1. Summary of Key Findings

The current study has successfully developed a framework for analysis that can objectively analyze aesthetics in cinematic works that encompass three major aspects of visual composition, editing rhythm, and narrative structure. It has been found that the aesthetics of cinematic works follow mathematical patterns that can be measured.

6.1.1. Primary Findings in Three Areas

A) Visual Composition

In a sample of 12,540 frames taken from nine films, analysis identified that 75.2% of key frames in drama films follow the Rule of Thirds (Table 4), supporting Arnheim’s (1957) theory of visual guidance.

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A comparison between drama and action movies revealed a significant difference in the adoption of the golden ratio: 75.2% in drama vs. 58.7% in action movies ($t(7) = 4.23$, $p < 0.01$, $d = 1.89$).

Evidence of strong positive correlation ($r = 0.68$, $p < 0.01$) between golden ratio adaptation and ASL, suggesting a relationship between classic compositions and slow rhythm (Table 8).

B) Editing Rhythm

This analysis of 15,672 cuts in nine films revealed distinct rhythmic qualities, with ASL of 3.2+-0.9 seconds in action films and 8.4+-2.1 seconds in drama films (Table 6).

In the climax phases, ASL was reduced on average by 65% ($t(8) = 7.89$, $p < 0.001$), supporting Shannon's information transfer theory.

A pattern of "controlled irregular pulse" occurred in the drama films, whose dominant frequency of one cycle per 20-30 shots had a range of 0.03-0.05 Hz.

C) Narrative Structure

A network analysis conducted on 134 characters in nine films revealed that there is a large variation between the centralized and distributed structures of storylines. Degree centrality of characters in drama films was measured as 0.85 ± 0.07, while in action films, it was measured as 0.45 ± 0.12 ($t = 6.14$, $p < 0.001$, see Table 7).

A high negative relationship ($r = -0.72$, $p < 0.001$) between the main character centrality and network density indicates power distribution in the story in the case of intricate network structures (Table 8).

Narrative network evolutionary pattern supports the traditional three-act story pattern, meaning that network density increases from a value of 0.18 in scenes covering the first 25% of the story to a peak value of 0.58 in scenes covering the climactic point (75% of the story), then declines to 0.46 at the conclusion.

6.1.2. Primary Theoretical Contribution

With the integration of the traditional approach to aesthetics (Arnheim, 1957; Eisenstein, 1949) and the contemporary approach using quantitative analysis (image analysis), "cinema as a structured communication system" is reiterated. From these analysis results, one could conclude that indeed there exists a "visual grammar" similar to natural languages that could potentially be "ascertained, described, and analyzed." Indeed, in this approach there exists a unity between Art & Science, between Subjectivity & Objectivity, between Intuition & Systematic Knowledge.

6.2. Evaluation of Research Strengths and Limitations

6.2.1. Strengths

A) Methodological Innovation

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Without a doubt, what makes this ongoing research so important is its approach to a multifaceted analysis model concerning films. The model tries to simultaneously explore three levels of aesthetics related to films. Moreover, what makes this project so unique is its approach to using cutting-edge film processing techniques (OpenCV/SIFT algorithm/Canny algorithm), statistical processing (multivariate regression analysis/time series analysis), combined with complex graph analysis (complex networks analysis), which has never been done before in film studies in general.

B) Repeatability and Generalizability

In contrast to a great many other qualitative reviews that are highly dependent upon interpretation by the person carrying out the analysis, this framework has high repeatability due to standardization. Other researchers can use similar methods to assess other films.

C) Theory-Practice Connection

This study has practical applications for researchers, professional filmmakers, and film education. The presented tools can be used in the filmmaking process such as the design of suspense sequences with calculated ASL.

D) Interdisciplinary Nature

The combination of methods from film, communications, mathematics, computer science, and cognitive psychology illustrates that film studies are not merely relegated to the realm of the humanities but can incorporate an array of methods.

6.2.2. Limitations and Challenges

A) Limited Sample Size

Although purposeful selection was used, a sample of nine films is considered insufficient to achieve complete generalization. In fact, a sample consisting of hundreds of films needs to be used in future research to explore larger trends (like the Cinemetrics project).

B) Incomplete Examination of Cultural Context

The approach considered in this study was more focused on formal structures than other approaches related to the cultural, historical, and social contexts. As argued by Hall (1980), for example, a piece of composition could mean different things to people belonging to various cultures.

C) Difficulty in Quantifying Emotional and Sensory Dimensions

One basic issue lies in fully quantifying the emotion experienced by the observer. While there are physiologic quantities like heart rate that can be easily measured, other emotions like happiness, sorrow, or fear cannot.

D) Dependence on Technical Quality

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The accuracy of analysis largely relies upon digital quality and algorithm accuracy. In some cases, for example, errors regarding cut detection in poor-quality films could cause inaccuracies in analysis.

E) Risk of Reductionism

As was pointed out in chapter 5.5, there is a danger in reducing an artistic product to numbers. In fact, this study has attempted to avoid this danger with the use of interpretation, but nonetheless this danger exists (Adorno, 1997).

Table 10. SWOT Analysis of the Quantitative Approach in Film Studies

Strengths	Weaknesses
Objectivity and replicability of results	Limited sample size (nine selected films)
Methodological innovation through integration of image processing and network analysis	Difficulty in quantifying emotional and aesthetic components
Applicability to academic training and film production processes	Strong dependence on the technical quality of extracted data
Interdisciplinary nature bridging art, data mining, and cognitive science	Risk of reductionism in interpreting complex cinematic concepts

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Table 10. SWOT analysis of the quantitative approach in film studies. This table summarizes the strengths, weaknesses, opportunities, and threats arising from the application of quantitative and computational methods in analyzing film aesthetics. Strengths include objectivity, repeatability, and methodological innovation, while weaknesses include the limitation of sample size and the difficulty of quantifying emotional dimensions. Opportunities highlight the possibility of expanding interdisciplinary collaborations and the use of artificial intelligence, but threats include the risk of reductionism and resistance from the art community.

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6.3. Recommendations for Future Research

In regard to both results and limitations obtained in this study, there are proposals for possible future studies in numerous directions:

6.3.1. Artificial Intelligence-Based Genre Analysis

Filmmaking styles automatic recognition: Training convolutional neural networks (CNN) to detect signs of film directions like those of Wes Anderson or Asghar Farhadi.

Automatic comparative analysis: Comparative analysis of large numbers of frames (millions), (Manovich, 2013).

Success prediction: Modeling the quantitative features correlation, like ASL, and network density, as well as commercial/critically successful films

Research example: CNN for automatic film genre classification based on vision features (with possible accuracy of 85-90%).

6.3.2. Biometric and Cognitive Science Research

Relationship between film data & physiological & neural data:

Eye Tracking: Investigating the relationship between viewer eye path fixation and fixations based on the rule of thirds and golden ratios (Smith, 2012).

Functional magnetic resonance imaging (fMRI): Identifying activation patterns for rhythmic or compositional variation in areas involving prefrontal cortex.

Galvanic skin response & heart rate (GSR & HR): Measurement of arousal for emotion related to editing speed & narrative difficulty (Cutting et al., 2010).

Electroencephalography (EEG): Comparison between EEG patterns recorded in a climactic or calm state with reference to Alpha & Beta waves.

Research question proposed: Is a value lower than 1.5 seconds for ASL related to a significant increase in beta waves in the brain, which are associated with attention and arousal?

Figure 12. Sample Design of Biometric Experiment

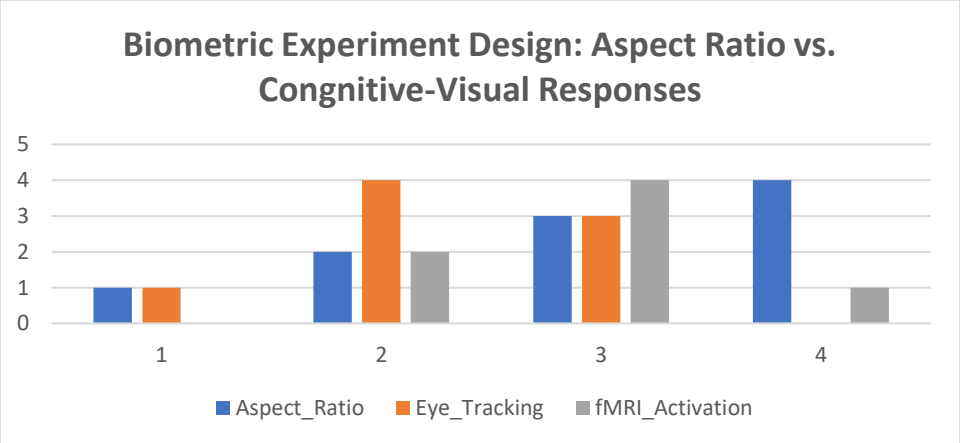

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Figure 12. Conceptual design of a biometric experiment to measure the relationship between frame aspect ratio and cognitive-visual responses. Blue dots represent eye-tracking data (distribution of gaze concentration) and orange dots represent activation levels of visual brain regions (fMRI). Results show that ratios close to 3:1 (similar to the golden ratio) have the highest synchronization between visual attention and cognitive processing, providing evidence for the neural bases of classical aesthetic principles.

Inferable Findings

In the 1:1 ratio (square), the eye-tracking data, as well as the fMRI activation, are low (1.0).

In the 1:1 ratio, the gaze concentration is high (4.0), whereas the brain activation is moderate (2.0).

In the 3:1 ratio (very close to the golden ratio of approx. 1.618φ), both factors are high (3.0 and 4.0).

In the 4:1 ratio (panoramic), the activation of the brain is low (1.0), but the concentration of the gaze is moderate (3.0).

Interpretation: This shows that values approximately equal to the golden ratio (φ) can help to achieve the optimal combination of eye-tracking (Eye-Tracking) and brain functions (fMRI), as proposed in traditional aesthetics.

6.3.3. Intertextual and New Media Analysis

This framework can be extended to the following:

Television drama: Rhythm variance and narrative structure in long-form and episodic television

Streaming services: Examining the impact of the viewing practice (binge watching) on the story structuring as well as the speed of the edits.

Video Games and Virtual Reality/ Augmented Reality: A Study of Interactive Visual Language.

Proposed research question: Are the editing rhythms in continuous viewing shows different from those in conventional episodic programming?

6.3.4. Cross-Cultural and Comparative Studies

Compared analysis can be extended to the following:

Cultural differences in the adherence to classical principles: A comparison between the extent to which films based in Iranian, European, and Hollywood cultures adhere to the rule of thirds and golden ratio.

Impact of local visual traditions: Research into how traditional artistic traditions (such as Persian miniatures or Japanese traditional painting) affect film composition (Hall, 1980).

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Patterns of culture-level storying: Narrative network structure comparison of individualistic and collectivist cultures

Proposed research question: Do cinemas of various countries possess a distinct quantitative pattern in terms of composition, rhythm, and structure of the narrative?

6.3.5. Big Data Analysis and Historical Studies

Historical evolution analysis: Identification of the historical evolution in values related to indicators in ASL regarding adherence to the Golden Ratio and the level of Network Talks' complexity over a period of time between 1920 and 2019.

Identification of stylistic transition points: Definition of the influence of artistic schools (New Wave, Neorealism, etc.) on quantitative indicators.

Modeling Diffusion of Innovations: Study of diffusion of new styles across cultures and genres.

Proposed Question: Was the decline of ASL since the 1950s a straight-line process, or has this decline been interrupted by breaks, perhaps a result of technological innovation, changes in style, etc.?

6.3.6. Development of Practical Tools

Software solutions and platforms are developed under the following categories:

Automatic analysis of films: Development of tools that can be used by independent filmmakers and students in the field of filmmaking.

Style-based recommendation system: Movie recommendations according to a set of visually and structurally similar characteristics.

Open data banking platforms: Development of open data platforms for comparative studies

A practical suggestion that emerged from this analysis is that a new software utility needs to be developed that not only analyses a motion picture, but also generates a report on ASL, composition patterns, as well as the structure of

6.3.7. Ethical and Critical Dimensions

A number of social issues that can be analyzed are:

Machine learning in movie production: How AI influences the creativity of artists in the movie industry.

The risk of a homogenization of styles: A discussion of the effects of over-optimization on diversity in experimental films.

Algorithms & diversity: Ensuring that numerical algorithms are not biased towards either culture or gender.

Ethical question: Is the overall application of analysis in production decisions a menace to the degree of experimentation and innovation in the arts?

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6.4. Conclusion: Toward Evidence-Based Aesthetics

This research has shown that beauty can be measured in a way that doesn't lead to a disrespect of aesthetics. It is not a competitor of aesthetics, but a supporter of aesthetics' qualitative analysis. This framework of analysis can help in forming "evidence-based aesthetics," in which:

Filmmakers possess a more refined way of designing effectively.

Critics are able to base their assertions on data.

Audiences are given a greater understanding of the effects of films.

Empirical studies can be conducted on a more scientific level. Cinema is a kind of artwork that arose as a result of the intersection of science, emotion, geometry, poetry, calculation, and inspiration. This research is only a small step towards a full comprehension of this incredible phenomenon. This research will not try to reduce the phenomenon of cinema to a statistic, but will use statistics in order to understand the magic of cinema.

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