Journal on Interactive Systems, 2022, 13:1, doi: 10.5753/jis.2022.2635

Systematic mapping of technologies for supporting choreographic composition

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Abstract

Technology has increasingly occupied other areas of sciences and humanities, including art and dance. Over the years, initiatives to use technological applications in artistic performances have been observed and this research is developed regarding this context and the challenge of using technology to support the artist's imagined creations. The systematic mapping of the literature carried out is part of a broad search for studies that portray the interdisciplinarity of these two universes, aiming to find technologies that support the choreographic composition process, focusing on tools that work together with the choreographer's activities. The methodology consisted of using search terms in research repositories, which initially returned 635 publications, which were filtered by inclusion and exclusion criteria, to undergo further analysis. Eighteen tools were identified and explored in which the main applicability was the simulation of movements through graphic animation. From the operating mode of these applications, the challenges of the existing relationship between technology and the creation of dance were discussed. This study only incorporates technologies that act as a support tool by sharing the compositional effort, which creates the opportunity for future investigations into other ways of using technology in dance creation. The main contribution of this paper is identifying and classifying the main integration strategies of technology and dance composition, as well as summarizing the data and discussing its implications, been the identification of the lack of involvement of artists (end users) in the early stages of the development process the most relevant finding.

Keywords: *Dance Creation, Choreography Composition, Choreography Design, Technology, Systematic Mapping*

1 Introduction

The use of technology in the artistic universe is a research area that requires interdisciplinary efforts between computer science and the human sciences and, therefore, has been the subject of studies in the academic world. Part of this interest can be explained by the evolution of computational capabilities and the accessibility to technological devices and tools by a large part of society. In 1996, Hill apud Sagasti (2019) listed approximately 100 published articles and books dealing with the interaction of dance with technology, and this number has been growing ever since.

The application of computation to dance composition, either as a support for choreographers or for related purposes, can be found in studies into the early stages of the emergence of computing, in the 1960s, to the present, and can be associated with goals, such as (Sagasti 2019) motion capture, storage and access; simulation of environments and the human body; control of resources associated with stages, such as lighting and scenic structures; real-time interactions; and using algorithms, neural networks and artificial intelligence to complement or even to replace the work of choreographers.

According to Lobo and Navas (2019), the expression 'choreography' has a Greek origin meaning "graphy of choral dances, group dances". However, the term began to be used to name any spellings or writings of the movement and was no longer restricted to collective dances over time.

Been the art of composing dance a product originated from the choreographer's imagination it becomes a research problem how to create technologies with capabilities of supporting the choreography composition process, since it is not only based on imagined constructs of dance such as movements and use of space, but also artists can present different skills and familiarity with technology solutions.

This work aims to carry out a systematic mapping identifying the technological tools that contribute as a support to the work of choreographic composition, to understand the state of the art in this field of research. It is worth emphasizing that the term support represents a range of ways to aid (Cambridge Dictionary 2021), that is, everything that facilitates or provides means of producing, transforming and/or visualizing movements or some other aspect directly related to dance, and that has some kind of interactivity with the choreographer, in order to share the compositional effort.

Computer science and human sciences are two areas that demand different study backgrounds, skills, and abilities and, therefore, can present challenges to end users inherent in both areas, such as limitations in knowledge in dance composition or lack of ease with the use of technological tools.

The identification and understanding, through historical chronology, of how the end user is positioned in the development of such applications and the characteristics of the tools can point out the main trends, challenges, and problems in the intercalation of the two areas and make researchers in the area aware of critical points. This leads us to the main motivation for this work: to support future work by providing the state of the art in this field of research.

This paper produced a mapping of supporting technologies in choreographic by identifying and classifying the main integration strategies of technology and dance composition. Besides provided chronologically the results, it also generated an infographic summarizing the categorization of the technologies found. The modus operandi of the tools was discussed, and it was verified a lack of involvement of artists (end users) in the development process.

The article is structured as follows: Section 2 presents the research methodology used to collect and to extract information from the articles found. Section 3 presents and discusses the results. Finally, Section 4 presents the conclusions of the study.

2 Research Methodology

The systematic mapping of the literature proposed by this research aimed to recognize and classify technological resources developed focusing on supporting choreographic composition, in addition to discussing aspects of the modus operandi of these tools. The methodology used here explores research questions, search protocols, selection, classification, and data extraction based on (Petersen et al. 2008).

2.1 Questions of interest

Given the main objective of understanding the state of the art in the use of technological tools to support choreographic composition, the following research questions were defined, to help mapping how the communication of both areas is implemented and how usability concepts are used, if applied:

- Q1: How do technologies work to support choreographic composition?
- Q2: How is the intercalation between technological resources and concepts of dance composition?
- Q3: Are usability concepts applied to technological solutions to support choreographers?

Research questions were determined to help understand the features of the tools. The first question is the starting point for extracting data from publications. The second question contributes to understanding the interdisciplinary relationship between dance and technology, in addition to seeking to list specific aspects between these two sciences. The last question seeks to understand the challenge of applying such technologies by identifying whether the application end users (choreographers and dancers) were involved in the research process and, therefore, whether the solution was developed seeking to meet the needs of dance composers, who, in turn, may have different levels of familiarity with computing.

2.2 Research and selection protocol

The authors conducted a systematic approach designed to identify and extract data from the studies. The first step consisted in defining a search protocol with search terms that cover an expressive and focused number of researches in the field of choreographic composition using technology. The search terms were: (“dance composition” or “choreography design” or “dance creation”) and (“software” or “technology” or “web” or “mobile” or “app” or “application”). The definition of these terms was made of the author’s agreement of using simple and generic words associated with the research, to get a large sample of records opposing to increase the specificity of the terms.

These terms were duly adapted to the restrictions of the repositories chosen and initially returned 635 records. The search terms used in each repository are shown in **Table 1** and the searches were carried out on July 17, 2021, without any type of date restriction, in order to include recent publications.

Table 1. Search expressions in digital libraries. Source: The authors.

Library	Search expression
Scopus	TITLE-ABS-KEY ("DANCE COMPOSITION" OR "CHOREOGRAPHY DESIGN" OR "DANCE CREATION" OR "CHOREOGRAPHY COMPOSITION") AND ("SOFTWARE" OR "TECHNOLOGY" OR "WEB" OR "MOBILE" OR "APP" OR "APPLICATION")
Springer Link	("DANCE COMPOSITION" OR "CHOREOGRAPHY DESIGN" OR "DANCE CREATION" OR "CHOREOGRAPHY COMPOSITION") AND ("SOFTWARE" OR "TECHNOLOGY" OR "WEB" OR "MOBILE" OR "APP" OR "APPLICATION")
ACM Digital Library	AllField: (("DANCE COMPOSITION" OR "CHOREOGRAPHY DESIGN" OR "DANCE CREATION" OR "CHOREOGRAPHY COMPOSITION") AND (" SOFTWARE " OR " TECHNOLOGY " OR "WEB" OR "MOBILE" OR "APP" OR "APPLICATION"))
IEEE Digital Library	(("All Metadata": DANCE COMPOSITION) OR ("All Metadata": CHOREOGRAPHY DESIGN) OR ("All Metadata": DANCE CREATION) OR ("All Metadata": CHOREOGRAPHY COMPOSITION)) AND (("All Metadata": SOFTWARE) OR ("All Metadata": TECHNOLOGY) OR ("All Metadata": WEB) OR ("All Metadata": MOBILE) OR ("All Metadata": APP) OR ("All Metadata": APPLICATION))

After the initial search process, duplicate documents (45) were eliminated and, of the remaining 590, inclusion (IC) and exclusion criteria (EC) were applied, as detailed in **Table 2**. Since for the same study more than one criterion could be applied in certain circumstances, the order of registration of the criterion was adopted. This step, conducted by one of the authors, reduced the search to 46 articles for complete reading and data extraction. It is noteworthy that three researches from the Scopus repository were not available for reading to the authors of this study.

During the reading task, publications (Alaoui et al. 2014, Carlson et al. 2015, Sagasti 2019, Zhang 2020) stood out for also bringing research work on the use of technologies in dance composition. From them, a snowballing process was carried out, which expanded the number of surveys included in the analysis. In this new process, 27 references were mapped to be added to the number of selected articles, but only 23 were found with available access. Additionally, it is important to point out that this procedure increased the total number of articles in some repositories, besides including others not initially planned.

Table 2. Inclusion and exclusion criteria set. Source: The authors.

Identifier	Description
IC-01	The study presents a technology used in the choreographic composition process
IC-02	Snowballing (entered directly through the references of some other study)
EC-01	Language other than Portuguese, English, or Spanish
EC-02	The study is not related to dance
EC-03	Technology is used as an actor or character and is not intended to support the work of choreographers (examples: focusing on robots, game characters, among others)
EC-04	Technology is used in/as a scenic element or accessory and not as a support tool in the choreographic creation process (examples: automated scenarios, projections, among others)
EC-05	Technology is used as a medium, be it for dynamic and real-time interaction, dissemination, storage, post-production, or related and distinct purposes from supporting choreographic composition (examples: digital files, video editing software, transmission tools in real time, among others)
EC-06	Works in which there is no evidence of the use of technology to create a dance in the title, abstract or body of the text (example: works with incomplete information)
EC-07	Studies that do not use any technology in the context of dance (example: exclusive discussions about dance)
EC-08	Studies that, despite involving dance and technology, do not demonstrate a relationship with choreographic composition
EC-09	False positive (example: surveys that present a discussion on the subject, yet superficial or inconclusive for this work)

The complete reading and data extraction processes were conducted by two authors and a third one contributed by solving divergences. The process consisted of a detailed reading from the authors and merge of the extractions of each author as the final data to be considered.

Only one article initially selected for analysis and extraction was classified as false positive. The work by (Felice et al. 2016) conducted an interview with six choreographers to identify the choreographic composition process to propose a framework that supports the construction of digital tools to assist in the creation of dances. However, no technology was theorized or developed within the scope of the study, not even a prototype. Therefore, the search classification was changed to the EC-09 exclusion criteria. **Table 3** compiles the number of records associated with each repository and their inclusion or exclusion criteria. A spreadsheet associating the searches found with the exclusion criteria is available at the link[1]. **Figure 1** shows an infographic that details the step numbers related to the research protocol and article selection. **Figure 2** shows the categorization (selected, rejected and duplicated) by year of the analyzed papers.

2.3 Data extraction and categorization

The information extracted from the articles identify 56 distinct technologies. When more than one research referred to the same technology, the publication that best described the tool or the most recent one was chosen.

It was used a standard form to collect details of technologies mentioned in the papers, focused on selecting or excluding applications that complied with the objective of the study and provided understanding about the modus operandi of the tools.

Figure 4 identifies and indexes the technologies extracted by the authors, ordered through year. Note that when the application name did not exist, the name of the first author of the study and a generic description were used (e.g., author`s software). To preserve the chronology of publications, duplicate records were kept and mentioned more than once, in addition to being referenced with the ID of the one technology to be considered. Moreover, it is important to emphasize that by the criteria of this research, even without applying publication year restrictions in repository searches, only one technology was selected in the last five years. A trend of how the technology is used over time is discussed in Section 3.

Additionally, some tools that were identified and approved in the inclusion criteria, due to their capability of use in choreographic composition, were filtered in an additional step that sought to find applications that actually operate as an accessory or work together with the participation of the professional in the act of composing, as expected, considering the main research goal.

Throughout the extraction process a thematic analysis, which consists of a method that aims at identifying, analyzing and reporting patterns or themes (Wohlin *et al*. 2012), was carried out to organize and present the technologies. This analysis was applied to selected and excluded technologies and categorized in two themes: output operation and method of interaction. **Table 4** shows the excluded technologies according to the operation output and method of interaction with users.

Regarding the output operation, the following categories were identified:

- Generation of new movements: From movements provided, either by a pre-defined database or by the user, the system generates new movements or sequences not previously listed in the application database.
- Movement transformations: From a sequence of movements, the system can apply processes, such as removal, repetition, reordering, transformation, etc. The base of predefined movements can be provided in the application or by the user.

[1] https://bit.ly/msl-tech-support-choreo.

Table 3. Records found by repository and classification by inclusion and exclusion criteria. Source: The authors.

	ACM Digital Library	IEEE Digital Library	Scopus	Springer Link	Other repositories	Total
IC-01	12	9	13	8	0	42 (6.5%)
IC-02	8	1	0	2	12	23 (3.27%)
Total inclusions (%)	**20** (30.77%)	**10** (15.38%)	**13** (20%)	**10** (15.38%)	**12** (18.46%)	**65** (100%)
EC-01	0	0	1	2	0	3 (0.45%)
EC-02	20	225	12	98	0	355 (53.79%)
EC-03	2	7	4	3	0	16 (2.42%)
EC-04	1	4	1	0	0	6 (0.91%)
EC-05	3	4	0	9	0	16 (2.42%)
EC-06	2	2	0	15	0	19 (2.88%)
EC-07	1	1	11	25	0	38 (5.76%)
EC-08	14	24	8	45	0	91 (13.79%)
EC-09	1	0	0	0	0	1 (0.15%)
Not found	0	0	3	0	4	7 (1.06%)
Duplicates	17	6	7	15	0	45 (6.82%)
Total exclusions (%)	61 (10.22%)	273 (45.73%)	47 (7.87%)	212 (35.51%)	4 (0.67%)	597 (100%)
Grand total (%)	81 (12.24%)	283 (42.75%)	60 (9.06%)	222 (33.53%)	16 (2.42%)	662 (100%)

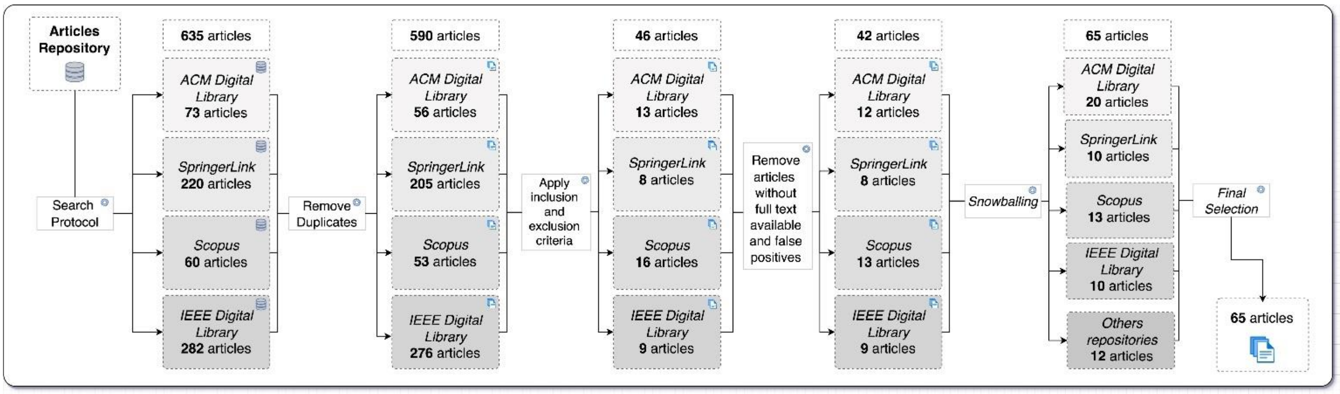

Figure 1. Research methodology used in systematic mapping. Source: The authors.

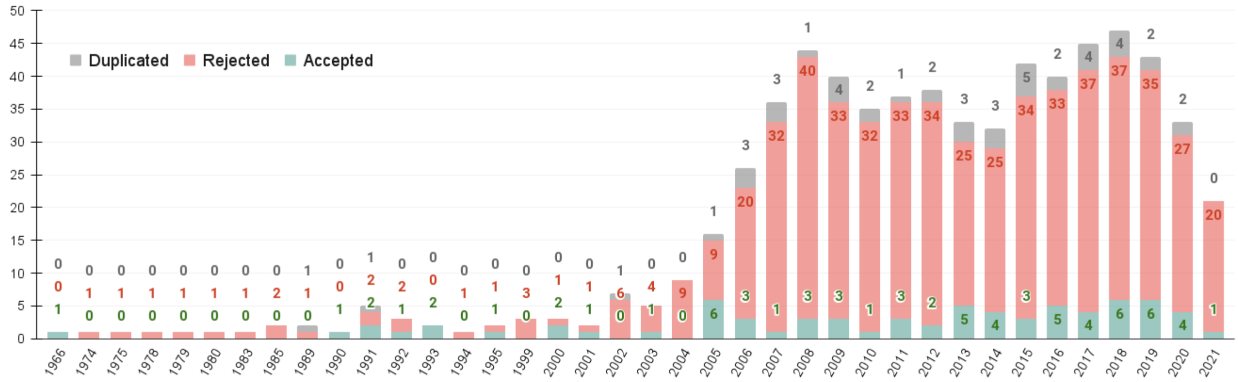

Figure 2. Categorization of papers by year. Source: The authors.

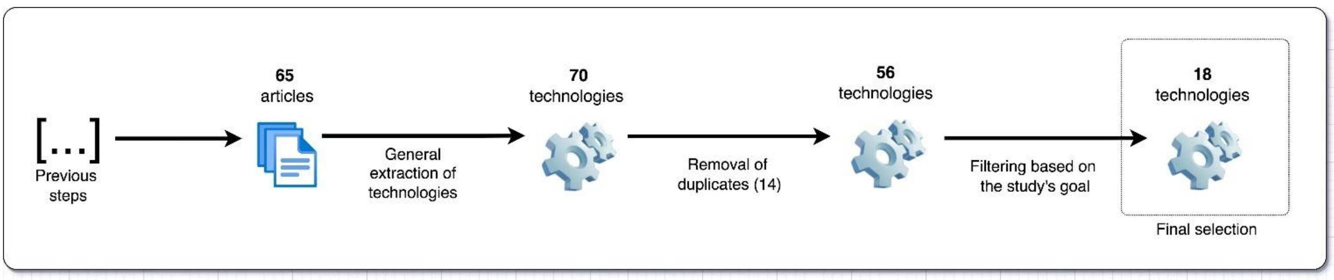

Figure 3. Identification and filtering of the technologies used from the articles selected. Source: The authors.

- Insights generation: The output of the application is not necessarily related to dance (e.g., sounds) or with specific attributes, such as stage positioning and timing. It requires a rule to be interpreted in the context of choreographic composition.

Table 4. Categorization of excluded technologies. Source: The authors.

		Interaction		
		Autonomous / independent operation	Tool configuration / parameterization	Inconclusive or out of context
Operation Output	Generation of new movements	[T17, T25, T31, T33, T39, T43, T44, T45, T46, T47, T48, T49, T50, T51, T53, T55, T56]	[T14, T20]	
	Movement transformations	[T11, T38]	[T18, T29]	
	Insights generation	[T9, T15, T28]	[T1, T3, T4, T8, T23]	[T34, T41]
	Inconclusive or out of context	[T35]		[T12, T16, T42, T54]

Regarding the interaction of the tool, the categories considered were:

- Autonomous/independent operation: The choreographer does not act in the process; he/she just starts the application and uses the result.
- Tool configuration/parameterization: The tool has internal setting parameters. It requires code change or basic knowledge of the core engine of the application.

In both analysis criteria, it is possible to find technologies whose description fits into:

- Inconclusive or out of context: Technologies found in the extraction process that were not explained in sufficient detail to understand their operation or output, or were applied outside the context of this research, that is, choreographic composition in dance.

In Section 3, we discuss some characteristics associated with the high number of exclusions. Finally, from the 56 different tools found, 18 were selected for descriptions of the modus operandi (as shown in **Figure 3**), to answer the research questions. **Figure** 4 presents a timeline with all technologies found, highlighting whether they were selected, excluded or already mentioned over the history.

The extracted data established to comply with the main objective of this study, was as follow:

1. Goal: It identifies if the developed tool helps the choreographic process (primary goal) or if it is a tool developed with different purposes but also used for choreographic composition (secondary goal).
2. Method of use: It informs how an interested person would be able to use the technology, which can be divided into: (i) mobile – specifically developed for mobile devices, such as tablets and cell phones; (ii) web – available through browsers; (iii) computer – any software or algorithms that run on computers; (iv) specific hardware – custom artifacts required to handle the tool.
3. Dance characteristics: It describes which technical aspect of dance is intended for the tool. In cases whereby there is no restriction to a specific modality, the tool was categorized as generic.
4. Final product: It focuses on describing how the objective is outputted, made available and/or represented to the user.
5. Notation system: If any, identifies which movement notation systems are used.
6. Movement interaction: According to Soga et al. (2001), there are some ways to describe human movement, which can be categorized into: (i) movement level – each specific part of the human body can be manipulated (e.g., Labanotation); (ii) steps level – some dances have combinations of small movements pre-defined and with specific nomenclatures (e.g., the movement "rond de jambe" in classical ballet); (iii) pieces/repertory level – in restricted cases, a large sequence of movements can be standardized, such as repertory ballets (e.g., Marius Pepita`s ballet piece The Sleeping Beauty).
7. Graphical user interface: It mentions whether or not it has a graphical interface for handling the system.
8. Operation description: It focuses on the application operating process.
9. Additional considerations: important information identified by the authors, not applied to the previous items.

The term "Undefined" was adopted in cases in which it was not possible to establish a clear conclusion. **Table 5** shows the result of the extraction process, detailing items 1 to 7 for each of the technologies selected. **Table 6** presents the operating characteristics of the tools (interaction and output of the system). A table with more detailed description and considerations about the modus operandi of the tools (Item 9) can be accessed at the link[2].

Moreover, it's important to note regarding the research protocol, according to Wohlin et al. (2012), the validation of a study denotes the confidence of its results, in order to guarantee that they are true and not biased by the researchers. The main threats identified throughout the research protocol are associated with reliability and generalizations, since data extraction depends on the authors' identification of the characteristics of the technologies. The mitigation of these threats was carried out by the following actions:

[2] https://bit.ly/msl-tech-support-choreo-modus-operandi

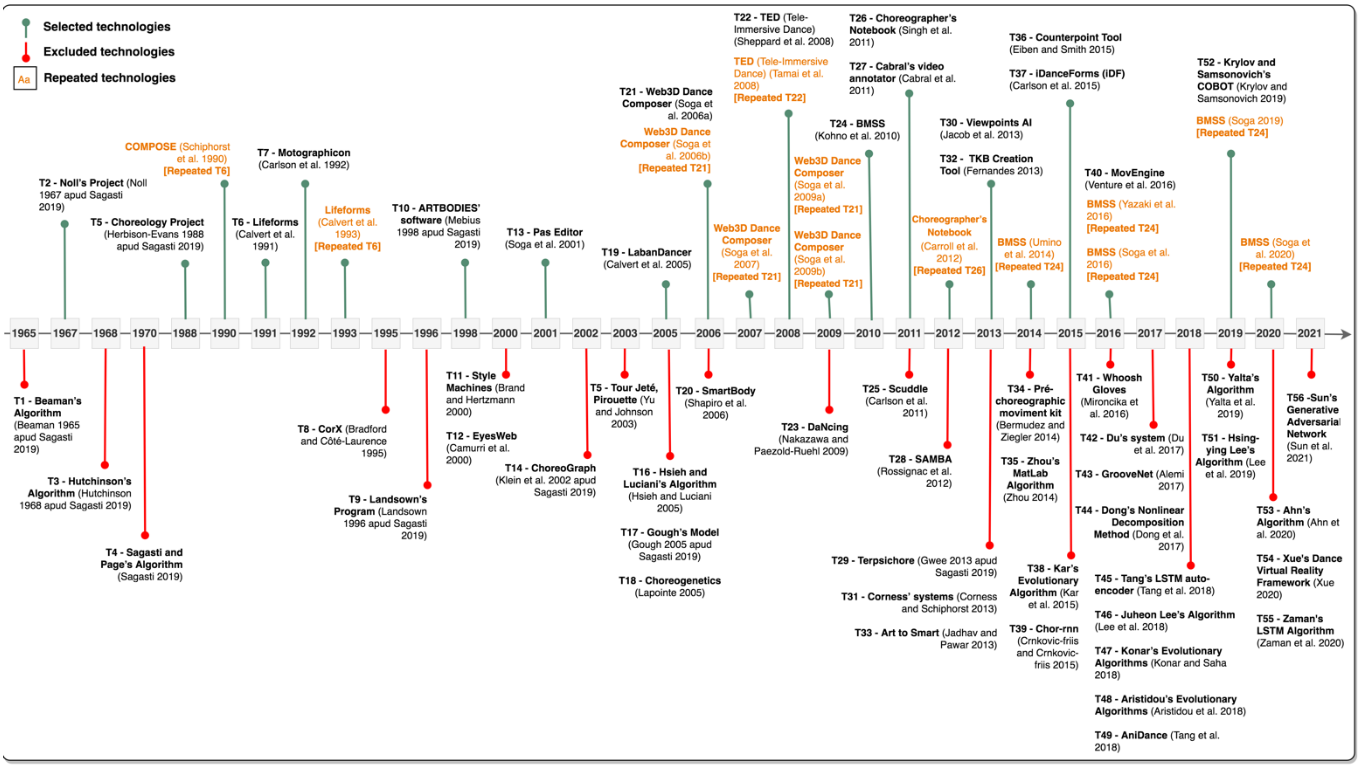

Figure 4. Timeline of the technologies considered in this research and classification in the filtering process. Source: The authors.

Table 5. Modus operandi of the technologies selected. Source: The authors.

ID	Technology	Goal	Method of use	Dance characteristics	Final product	Notation system	Movement interaction (level)	Graphical User Interface
T2	Noll's Project	Primary	Computer	Generic	Graphic Animation	Undefined	Steps	Yes
T5	Choreology Project	Secondary	Computer	Classical Ballet	Graphic Animation	Benesh Notation	Movement	Undefined
T6	Motographicon	Primary	Computer	Generic	Graphic Animation	Peter Rajka Symbolic Notation	Movement	Yes
T7	Lifeforms	Primary	Computer	Generic	Graphic Animation	None	Movement	Yes
T10	ARTBODIES' software	Primary	Computer	Generic	Graphic Animation	Undefined	Movement	Undefined
T13	Pas Editor	Primary	Web	Classical Ballet	Graphic Animation	None	Steps	Yes
T19	LabanDancer	Primary	Computer	Generic	Graphic Animation	Labanotation	Movement	Yes
T21	Web3D Dance Composer	Secondary	Web	Classical Ballet	Graphic Animation	None	Steps	Yes
T22	TED (Tele-Immersive Dance)	Primary	Web; Specific Hardware	Modern Dance	Video Interaction	None	Movement	Yes
T24	BMSS	Primary	Specific Hardware	Generic	Graphic Animation	None	Steps	Yes
T26	Choreographer's Notebook	Primary	Web	Generic	Video Interaction	Undefined	Undefined	Yes
T27	Cabral's video annotator	Primary	Mobile	Generic	Video Interaction	None	Undefined	Yes
T30	Viewpoints AI	Secondary	Computer; Specific Hardware	Generic	Video Interaction	Undefined	Movement	Undefined
T32	TKB Creation Tool	Primary	Mobile	Generic	Video Interaction	None	Undefined	Yes
T36	Counterpoint Tool	Primary	Web	Generic	Graphic Animation	None	Undefined	Yes
T37	iDanceForms (iDF)	Primary	Mobile	Generic	Graphic Animation	None	Movement	Yes
T40	MovEngine	Primary	Computer	Generic	Graphic Animation	Eshkol-Wachman Movement Notation; Labanotation	Movement	Yes
T52	Krylov and Samsonovich's COBOT	Primary	Computer	Generic	Graphic Animation	None	Steps	Yes

- The extraction of data was made by two authors and a third one resolved conflict.
- A data extraction form, with objective and direct items, was used in an online tool for supporting literature reviews (Parsifal, 2021).
- It was included the options "inconclusive", "out of context" or “undefined” in the extraction items to portray the lack of information in the categorization of technologies and to minimize subjectivity and assumptions in the act of extraction.

3 Discussion and Results

This section discusses the results from the questions proposed in this research, relating them to the information acquired from the data extraction.

- Q1: How do technologies work to support choreographic composition?

From the analysis of the articles initially selected and with the identification of technologies that aim to support the choreographic composition process, it was possible to observe that there is a concentration of tools in two categories: movement simulation through graphic animation (72.3%) and digital interaction in video content (27.7%), summarized in **Table 6**.

Table 6. Categorization of selected technologies based on interaction and operation output (item 9). Source: The authors.

		Operation Output	
		Graphic animation	Video interaction (*off-line* or real-time)
Interaction	Application interface	[T2, T7, T10, T13, T21, T24, T36, T37, T52]	[T22, T26, T27, T30, T32]
	Movement notation records	[T5, T6, T19, T40]	

Graphic animation outputs manifested different characteristics between technologies. **T2** and **T24** produced animations in stick figures, and similarly, **T13** and **T21** offered a skeleton visualization, while **T7** mentioned the use of animations with cartoons. **T5**, **T6**, **T19**, **T37**, **T40** and **T52** set out to work with humanoid bodies. **T10** explicitly mentioned the use of animations but gave no indication as to whether they would be stick figures or humanoid bodies.

The ability to move a human body, at first, seems advantageous given the number of details that can be worked on, even if the complexity of the tool increases. However, no study has discussed or presented solutions for the diversity of bodies and consequently diverse motor skills present in the dance universe, forcing the choreographer to create using very specific bodies whose idealized movements dancers may not be able to reproduce. Applications with stick figures or symbolic images of human bodies (cartoons) can be seen as a solution to reduce this restriction, however, it limits the visual richness in the final product and loses the appeal of using such tools.

T22 and **T30** proposed the virtualization of bodies, through motion capture sensors, such as Kinect, and allowed the generation of graphic animations with insertions of other virtual objects (augmented reality). However, in these cases infrastructure and equipment were needed, which not only restricted movement throughout the space, but also represented extra expenses and investments, opposing to the technological apparatus of other technologies that required simpler equipment such as computers, notebooks, smartphones and/or tablets. **T24** mentioned the use of a touch screen panel, in the first citation in 2010, and the latest version, from 2019, the tool was adapted to computers.

The technology with the simplest animation generation was **T36**, whose focus was restricted to the use of space by dancers. By using particles to represent people, the application has become simplified, but despite dealing with one of the inherent elements of a choreography, which is spatial movement, it does not offer help regarding body movement details. As Calvert et al. (1993) noted, users sometimes prefer a simpler, more abstract representation, since it's still possible to represent movement patterns and it offers less distractions than more realistic models that draw attention to aspects which depart from reality.

Moreover, tools whose output was video interaction (**T26**, **T27** and **T32**) made possible what no previously mentioned tool was capable of: preserving bodies and natural mechanics. However, it started from the input of previously recorded videos of real dancers and requires initial work before using the tool, in addition to being restricted to drawings, annotations and comments.

It is important to highlight that, according to the information provided in **Figure 4**, it was clear that numerous tools were excluded from the final selection. This is because the field of arts is directly associated with creativity. Thus, any type of interaction with any event or object can be used, even if minimally, as inspiration. Hence, this event or item could be understood as support. However, Carlson et al. (2015) reinforce that many current technologies do not allow creative compositional choices and do not help in the process of designing dance movements and choreographies. Tools, such as Photoshop, Blender and Microsoft PowerPoint, provide a blank space for inputting ideas, and even a generator of numbers, images or random words could contribute, but they do not necessarily offer artistic assistance. Another feature found were tools that use artificial intelligence for automatic compositions, which drastically reduces or eliminates the choreographer`s participation in the process, as shown in **Table 4**.

It was noted a trend in using artificial intelligence nowadays, which restricts the involvement of the choreographers in the tools using this strategy. The fact that, in the latest five years only one technology was selected to this study, can be explained by this tendency of using such no inclusive or purposely exclusionary strategies. The tool that best presented an effort sharing relationship was **T52**, as it applied computational intelligence to suggest viable options for transitioning between inserted movements and the choreographer should choose which option to use.

- Q2: How is the intercalation between technological resources and concepts of dance composition?

It was found that the most practiced form of intercalation between technological resources and specific concepts of dance creation occurred through movement notation systems. These tools aimed to understand how dance should be performed converting notation scores to allow choreographers to visualize a graphic animation of their ideas. A notation consists of characters, signs, or registers that, connected together, create new forms with different meanings. The most common movement notations today are the systems created by Laban (Labanotation), Benesh and Eshkol-Wachman (Dania et al. 2015). **T19** exclusively used Labanotation while **T40** also included Eshkol-Wachman Movement Notation. **T5** was developed with Benesh Notation. It is noteworthy that **T6** proposed to use Peter Rajka Symbolic Notation developed exclusively for the tool, which would make the use of such technology even more complex and with the requirement to study a non-popular notation.

Ribeiro et al. (2017) contrasts the music universe and its globally readable scores with the universe of dance and the lack of a notation widely known from the latter. Carlson et al. (2015) also highlights the challenge of developing an international standard and discussions about the creation of LabanXML or, more broadly, DanceXML, which would open opportunities for creating diverse tools that could share resources with each other if they adopted a convention on how to represent dance digitally.

Another form of intercalation is using libraries of movements or known dance steps that are made available to the user to compose a choreographic sequence from; however, this strategy is limited to the application steps database.

The dance characteristic in the technologies proved to be crucial only in the **T5** tool that used Benesh, a notation focused only on classical ballet, and it was also noted to be influential in the tools that used the movement interaction level as “steps”, since a specific database is required and therefore can be chosen to restrict to one dance style only.

- Q3: Are usability concepts applied to technological solutions to support choreographers?

The studies did not focus on usability, by not performing enough research with end users in the requirement gathering process. The main trend in the studies was to focus on the quality and methods of movement manipulation, be it through body parts or existing steps, and on the form of visualization. Still, it notes that of the 18 selected technologies, eight explicitly pointed out some basic type of end-user involvement during the tool development or experimentation process, even though such engagement was not prioritized in the definition of the functional requirements.

T6 had an interdisciplinary development team that included choreographers, the number of members and their experience was not mentioned.

T21 involved five ballet teachers with experience ranging from 7 to 25 years just in the process of evaluating some of the automatically generated products. The authors were able to extract some considerations around the evaluation and interview with teachers, such as suggestions for expanding the step database, improving the algorithm responsible for transitions and the ability to generate memorable content. It is not clear whether these teachers were involved in the creation of the tool.

T22 also tested the tool with groups of dancers/choreographers and dance critics, storing it through video and collecting data through questionnaires to identify improvements, priorities, and limitations, with the main challenges found associated with 3D cameras/sensors having limitations in the area they can cover and the infrastructure to transfer the captured content must be of high quality to guarantee quality of processing and visualization of graphic animations.

T24 conducted two experiments with undergraduate and majored students trained in dance in addition to filling out a questionnaire. They concluded that the tool is useful for students to discover new movements and choreographic processes and graduates can be aided by the tool, but it requires them to use their practical expertise to improve the final artistic production.

T26 carried out an ethnographic study with focus groups and interviews using the tool. A choreographer recorded a set of dancers and later used the tool to enter comments. Despite being well evaluated, it was possible to extract suggestions for improvements to the system.

T27 and **T32** mentioned the presence of a choreographer in the research team, but it was not explicit in which stages of the research, in addition to the use of the tool at the end, the choreographer's contribution was made.

Finally, **T52** conducted a form with 14 volunteers who experienced the tool's output, however, none were described as being dancer or choreographer.

Although some end-user interventions were mentioned above as part of some stage of the papers, only one research (Felice et al. 2016) among all the articles investigated, presented a conceptual mapping work of a technology aimed at digitally assisting choreographers, based on interviews with potential end users.

Overall, it was possible to observe that the main role of technology has been the simulation of movement through animations, with the conversion of motion notation systems being the most characteristic intercalation between computer science and the arts of choreographic composition. **Figure 5** presents a conceptual map based on all the technologies listed during the research process summarizing and associating it with interaction and operation output (refer to **Figure 4** to associate the technology index with its name and references).

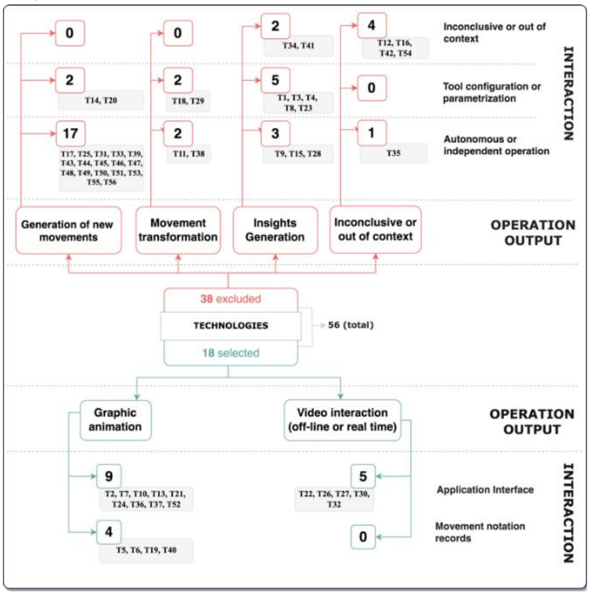

Figure 5. Research methodology used in systematic mapping. Source: The authors.

4 Conclusions

This study conducted a systematic mapping of technologies used as support for choreographic composition over time. The research process started from a broad search that included 662 articles, which were reduced to 65 for a detailed analysis of their contents, resulting in the identification of 56 different technologies, of which 18 were selected, as summarized in **Figure 3**.

Movement simulation through animation was the main application of technology in the analyzed tools and conversion of notation systems was the most unique characteristic of the interdisciplinarity between these two research fields.

This paper contributes mainly by identifying and classifying integration strategies of technology and dance composition in developing tools for support purposes. It chronologically analyzed different types of software and their modus operandi, showing a lack of any sort of usability techniques in the development process of such applications. The findings imply that academic research must increase the involvement of artists in the early stages of modeling technology solutions to understand the practical demands of choreographers and aspiring dancers.

The research restriction to focus only on technologies that act as a support tool by sharing the compositional effort is a limitation of this study, since it reduces the number of studies selected.

Future investigations might include other ways of using technology in dance creation such as using computer vision and motion capture, virtual and augmented reality, machine learning to generate suggestions as the choreographer creates, web-connected applications to allow geographically distant cooperative work and internet of things with the development of specific hardware. Additionally, there is opportunities for a philosophical discussion over the limits of technology intervention/contribution, in order to do not cross the tenue line that divides art and a mere technological product without artistic value.

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