

InTouch: Rethinking Annotation and Note-taking in Tactile Graphics and Visualizations

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ABSTRACT

Annotation is an interaction technique that allows for the addition of textual or graphical context to data elements. When initiated by a user, the action of annotating can range from tagging data or text with labels, adding notes or highlights, to leaving explanatory comments to regions of interest. In traditional visualizations, annotation has been formally characterized and extensively studied as a technique to support sense-making, storytelling, and collaborative analysis. However, annotation in physical, non-visual media, specifically in tactile formats such as braille and tactile graphics, remains underexplored from the perspective of users who are blind or visually impaired. This position paper highlights the need to formally characterize annotation as an interaction technique in tactile modalities. We summarize current practices in tactile annotation from the literature and practical scenarios from the community, through which we examine their limitations in terms of agency, precision, and collaborative support. This work contributes to a broader goal of making interactive visualization more inclusive by understanding and addressing accessibility at the level of interaction techniques, not just output formats.

Index Terms: Accessible visualization, tactile, annotation, BLV.

1 INTRODUCTION

Within the field of data visualization, annotation has been formally characterized in systematic frameworks. Munzner’s visualization taxonomy conceptualized annotation from two complementary perspectives [24]: the high-level user goal it serves, and the low-level interaction method used to perform it. As a high-level goal, annotation is a *Produce* action, where the user’s primary intent is to create a new artifact by enriching the visualization with their own insights. This goal is achieved through the interaction method of *Introducing* new graphical or textual marks onto the medium, often linked to specific data elements [2]. Recently, the diverse features of common annotations in visualizations have been characterized through Rahman et al.’s design space [28].

Annotations serve multiple functions across the visual analysis workflow. For analytical reasoning, studies show how annotation tools can integrate into every step of a visual analytics pipeline, from data preprocessing to result presentation [31]. In narrative contexts, annotation is essential for guiding a user’s path, whether through interactive timelines that turn complex datasets into coherent stories [3] or by using textual callouts to stitch together different views into a compelling narrative [32]. The practice is equally vital for collaboration, where features like threaded comments, graphical marks, and shared bookmarks have been shown to support asynchronous discussion and collective discovery [13].

However, annotation as an interaction technique has been developed and examined primarily within the context of visual interfaces, which are largely inaccessible to blind and low-vision (BLV) users. Accessible visualization forms are important resources for BLV users to access and interact with data and information [17]. Tactile forms and materials have been recognized as an effective

and accessible means for enabling and enriching data exploration. These materials range from raised-line drawings that use continuous ridges to outline shapes, comprehensive tactile graphics that combine varied textures and Braille to represent charts, maps, and complex diagrams in accessible formats [27]. Over the years, these materials have evolved considerably, from simple embossed paper to sophisticated 3D-printed physicalizations that enable rich spatial exploration through touch [37]. When commercial tactile toolkits do not fulfill the creative needs of the BLV community, a do-it-yourself (DIY) approach is often adopted to annotate and personalize existing tactile graphics and drawings, modifying existing graphics by hand, using collage techniques with materials like wax-coated yarn or puff paint to add braille labels, different textures, or physical markers to highlight findings and add notes [5].

While these ad-hoc crafting methods demonstrate a clear, user-driven need to mark and engage with tactile data, the very annotation capabilities and interaction techniques remain largely underexplored in tactile formats. Tactile annotation as an interactive technique is yet to be systematically characterized to support accessible tactile data exploration. This paper builds a foundational understanding by synthesizing existing knowledge and proposing a structured way forward. We begin by surveying the academic literature to understand how tactile interaction is currently studied. We then complement this with a review of the creative annotation practices currently employed by the BLV community. Drawing from these findings, we propose a descriptive framework of tactile annotation from its modality, function, and social contexts.

2 CURRENT PRACTICES IN TACTILE ANNOTATIONS

In this paper, we use the term “annotation” to refer to additional marks or labels that are added to aid sense-making, direct perceptual focus, or convey interpretive insights beyond the base translation of a visual into tactile form. This definition is related to braille and symbolic labeling strategies in tactile graphics guided by standards such as BANA guidelines [1], which can inform annotation design. However, these strategies mainly aim to encode and translate visual information in a standardized way, rather than to provide user-driven and interpretive commentary. Our focus here is on understanding tactile annotations as an interaction technique for enriching exploration and interpretation. We examine existing practices from two complementary perspectives: academic research and community-driven approaches. This descriptive analysis reveals the current practices while highlighting patterns in technique adoption that inform our subsequent framework development.

2.1 From The Literature

We conducted a targeted literature search using relevant keywords across major venues in visualization, accessibility, and human-computer interaction. These venues included IEEE TVCG, VIS, Pacific VIS, ACM ASSETS, CHI, CSCW, and UIST. The search terms intentionally did not include very specific terms such as *emboss*, *sticker*, or *label* to discover the research landscape rather than presupposing which techniques matter. Our search yielded an initial set of 265 papers. We then refined this corpus by manually excluding papers where keywords were used metaphorically rather

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Table 1: Summary of tactile annotation techniques described in selected literature, with details on method, interaction, purpose, and authorship.

SOURCE	ANNOTATION METHOD	MEDIUM	INTERACTION	ANNOTATION PURPOSE	AUTHORSHIP
			creation access		user system
TacNote: Tactile and Audio Note-Taking... Lee2023 [18]	Personalized Tactile symbols with audio notes.	3D pen, PVC sheet, mobile application.	Free-hand drawing of tactile symbols and marks; Recording digital notes via text or voice input. Finger-pointing on symbols to trigger recorded audio annotation.	Labeling and note-taking on everyday objects.	user
Tactile Data Comics... Sun2025 [35]	Step-by-step presentation of tactile graphics and Braille labels + synchronized audio narration.	Refreshable Tactile Display (RTD).	Sequential tactile exploration of dynamic graphics paired with audio narration.	Instructional explanation and stepwise comprehension of complex learning concepts.	system
AccessibleCircuits... Chang2021 [4]	3D-printable tactile add-on + conductive components for audio feedback.	Physical breadboards; 3D-printed add-ons; smartphone.	Touching conductive proxies triggers audio and Braille reading.	labeling components and locations in circuit prototyping.	system
The Cross-Sensory Globe... Ghodke2019 [10]	Detachable tactile parts + audio stickers.	3D-printed components; PenFriend audio labeler.	Haptic exploration of detachable 3D parts; using audio pen on stickers to retrieve audio annotation.	Labeling and spatial explanation in geography learning.	system
Explore, Create, Annotate... Pandey2020 [25]	Audio labels + Braille labels + tactile markers on tactile drawing.	Tactile maps on swell paper.	User-driven drawing and labeling on tactile diagrams; audio annotation through gestures and voice. Accessing tactile labels through touch; trigger audio description through gestures and voice commands.	Labeling features on a map.	user
TacTILE... He2017 [11]	3D-printed tactile overlays with cutouts overlayed to an on-screen graphic with audio annotations.	Touchscreen device; 3D-printed overlay; custom application.	Designer uses GUI to link audio to image regions. Tapping through cutouts on the physical overlay to trigger audio annotations.	Adding audio descriptions to graphics.	system
Tactile Materials in Practice... Phutane2022 [27]	Tactile crafting and label placement using a variety of low-tech and DIY methods.	Real objects; 3D models; tactile graphics (swell paper); arts & crafts supplies.	Manual crafting by teachers/students using tactile kits, puffy paint, etc. Direct tactile exploration during lessons.	Instructional labeling and emphasis in teaching environment.	user
Tickers and Talker... Shi2016 [33]	3D printed percussion markers + audio labels.	3D models + phone with microphone + custom application.	Designer adds Tickers to a 3D model and records audio labels by strumming each one. User strums a Ticker to trigger sound recognition and playback of the audio label.	Audio labeling of 3D-printed model components.	system
Markit and Talkit... Shi2017 [34]	Computer-vision-based audio annotation on 3D models.	3D models, camera-equipped PC.	A maker uses software to associate text annotations with surface areas of a 3D model. User touches model with a stickered finger, triggering vision-based recognition and audio playback.	Spatial audio labeling via finger tracking.	system
TouchCast... Takeuchi2012 [36]	<i>Tactile Copy & Paste</i> to scan real-world textures and apply them to digital illustrations.	Custom browser extension; tactile pen with vibrotactile feedback.	Scanning textures from real objects as audio signals and applying them to digital illustrations. Sharing and exploring the created tactile content on a tactile display.	Creation and sharing of personalized tactile experiences.	user
From Sight to Touch... Ebermann2024 [8]	Tick marks, raised lines and various textures.	3D-printed physicalizations of bar charts, line charts and pie charts.	Direct tactile exploration of physical charts, including legends, grids, and labels.	Data differentiation using tactile encodings.	system
When Refreshable Tactile Displays... Reinders2025 [30]	Conversational + tactile.	Refreshable Tactile Display (RTD) + speech.	Touch + speech for query and navigation.	Interactive data querying and navigation.	system

than in their specific, technical context. The final corpus consisted of 12 papers relevant to tactile annotation.

Literature Search Keywords

("Braille" OR "tactile" OR "visual* impair*" OR "blind" OR "BLV") AND ("annotat*" OR "note" OR "highlight*" OR "mark*" OR "add*") in Document Title or Abstract

We analyzed each study across five key dimensions to identify commonalities in how researchers are currently approaching this problem space of tactile annotations (Tab. 1).



Annotation method captures the core technique or modality used to annotate information in tactile form. This includes physical labels, texturing, or audio notes.



Medium describes the physical or digital platform where the annotation is created, applied, or experienced. These range from swell paper and 3D models to RTDs.



Interaction characterizes how users engage with the annotations from two perspectives: ● *creation* describes how an annotation is authored, while ● *access* describes how the end-user retrieves its information.



Annotation purpose identifies the functional goal or communicative role of the annotation as well the purpose of the annotation within its broader application domain.



Authorship indicates whether the annotation was generated by the user or provided by the system. This distinction helps us understand the degree of agency afforded to users in contributing annotations. We categorized each case as either ● *user-generated* or ● *system-generated*. User-generated con-

tent is created by the end-user, often for personal use. Examples include a person with a visual impairment creating their own tactile notes with a 3D pen and recording corresponding audio, or teachers and students co-creating custom materials for a specific lesson. In contrast, system-generated content is pre-authored by a designer, researcher, or maker as an integral part of the tool or artifact.

2.2 From The Community

While academic studies offer valuable insights into tactile materials and graphics, much of the real-world innovation in annotation happens outside formal research. To paint the complete picture, we drew from hands-on maker tutorials, educator blogs, social media discussions, and resource websites from American Printing House for the Blind ¹ and Paths to Literacy ². Notably, many grassroots techniques borrow from non-visualization contexts, which are included as annotation techniques as inspirations to inform richer and more intuitive ways to annotate tactile charts and visualizations. These community practices were organized into six dimensions based on their underlying tactile encoding. We provide examples for each and illustrate how they span a variety of functions.



Braille & symbolic annotations rely on textual and symbolic encodings to convey explicit linguistic information.

This category includes Braille labels and other raised character systems that allow users to identify, name, or describe elements within a tactile space. A braille label can be prepared manually or using Dymo-style devices that emboss Braille onto adhesive vinyl tape as stickers. These labels appear on household items, medication bottles, file folders, and classroom tools as they empower BLV users to manage information independently [6].

¹ www.aph.org

² www.pathstoliteracy.org

illustrative snapshot of community tactile annotations

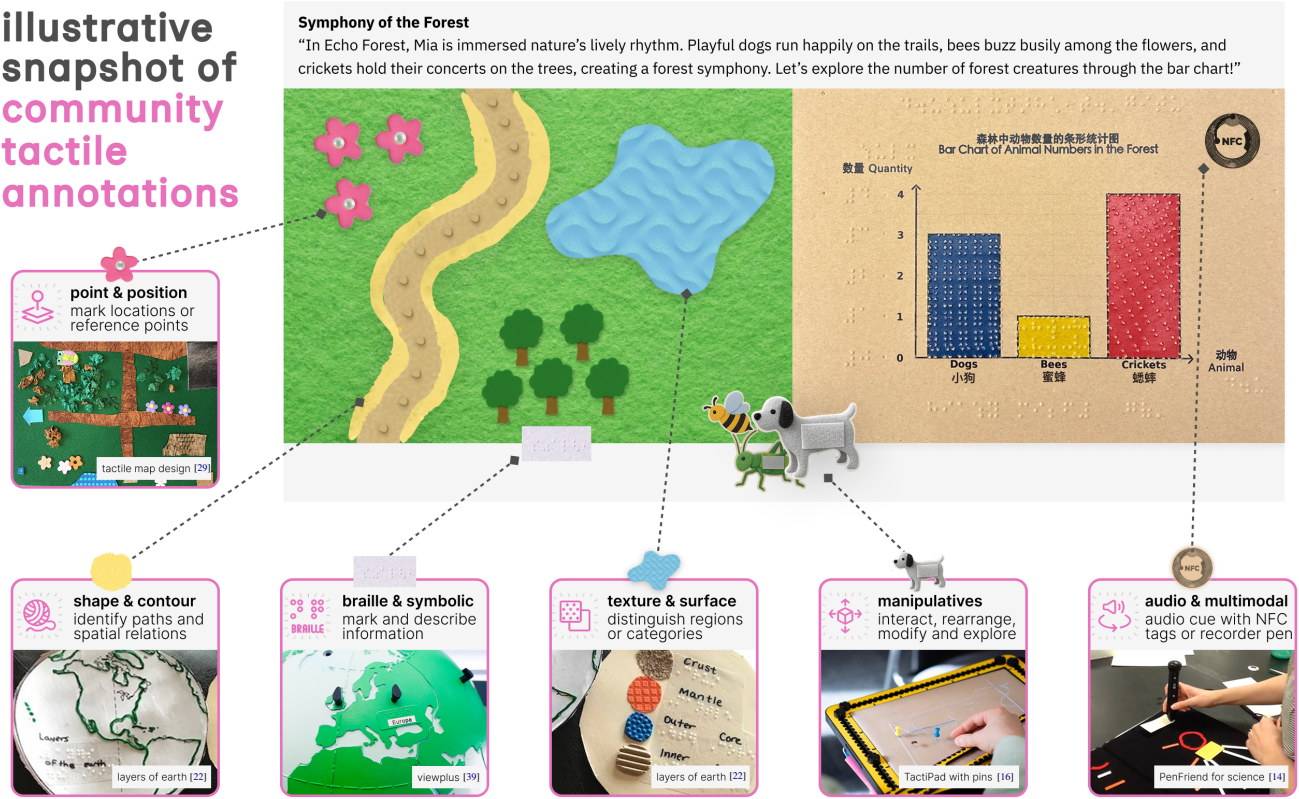


Figure 1: Illustrative scene based on the DataStory project [12], integrating community-driven tactile annotation techniques across six categories. Each annotation category is illustrated by an example community use case.



Shape & contour annotations use raised lines and contours to define paths, boundaries, or spatial relationships. This technique focuses on communicating structural or geometric information through tactile form. Materials like puff paint [26] and hot glue [15] are used to draw durable lines on paper or board surfaces, while Wikki Stix and pipe cleaners provide flexible, repositionable alternatives [16].



Point & position annotations highlight specific locations or reference points within a layout. With common materials like bump dots or small tactile stickers [21], these markers signal key positions, such as buttons on appliances, intersections on diagrams, or reference nodes in learning tools. Their size, shape, and placement allow for quick recognition and are often customized to support individual preferences or residual vision.



Texture & surface annotations distinguish regions or categories using material contrast. Community creators draw from a wide palette of craft and hardware materials: sheets of felt, sandpaper, corrugated cardboard, craft foam, and various fabrics are cut into shapes to represent different areas on a map or different bars on a graph [9]. The guiding principle is to select textures that are clearly distinguishable from one another by touch [38]. Texture and surface cues can also be used simply to provide an enriching tactile experience [27].



Audio & multimodal annotations integrate sound to enhance or offload tactile content. These multimodal practices are common in educational and museum settings, where devices like the PenFriend allow users to record and play

back audio linked to adhesive stickers [19]. This method enables tactile graphics to convey detailed explanations or instructions without adding tactile clutter. For example, a sticker on a science diagram might play "This is the mitochondria" when touched [14].



Manipulatives & interactives annotations introduce physical interactivity and user-driven exploration. In this category, annotations are not fixed marks but elements that can be rearranged or manipulated. Common examples include Velcro-backed pieces in tactile storyboards [20], or string-and-pin setups for graphing exercises [16].

To synthesize these practices into a unified case, we created an illustrative snapshot scene (Fig. 1) based on the DataStory project [12]. The original project designed a tactile storybook that combined tactile charts with a storyline and data sonification. We now expand upon it and enrich the experience with a tactile map to demonstrate the six major annotation types found in community practice. In this snapshot, readers explore the tactile map and chart by following a winding trail, where *braille & symbolic* symbols provide location labels; raised contours define the *shape & contour* of the paths; *point & position* markers represented by craft stickers mark locations in the storyline; *texture & surface* annotations distinguish areas, from grassy plains to a rippling lake. NFC-tag triggered narration and data sonification on the chart for *audio & multimodal* annotations. Animal models act as *manipulatives & interactives* that can be moved along the path as the storyline progresses. Each annotation in the snapshot is paired with an inset image showcasing a corresponding real-world community example.

Table 2: Tactile Annotation Framework: A design consideration checklist across content, modality, form, function, spatial and social aspects.

CONTENT FOUNDATION	ANNOTATION MODALITY	REPRESENTATIONAL FORM	SEMANTIC FUNCTION	SPATIAL ANCHORING	SOCIAL SCAFFOLD
<i>What's being annotated?</i>	<i>What's the mode?</i>	<i>How's it manifested?</i>	<i>What's the purpose?</i>	<i>Where's it positioned?</i>	<i>Who creates/accesses it?</i>
☐ Textual Content <i>Braille documents, tactile books, primarily linguistic materials encoded through raised dot patterns or raised text</i>	☐ Textual <i>Braille, raised text, symbolic and linguistic information</i>	☐ Physical Additive <i>Discrete objects onto or alongside the tactile surface: pins, tokens, rubber bands, adhesive materials</i>	☐ Identifying & Labeling <i>Assigning names or identifiers to elements; labeling categories</i>	☐ Fixed <i>Placed directly on or adjacent to the target.</i>	☐ Personal <i>For an individual's private sense-making or note-taking</i>
☐ Graphical Content <i>Tactile graphics, maps, diagrams, data visualizations, spatial representations encoded through shape, texture, and spatial arrangement</i>	☐ Graphical <i>Tactile shapes, icons, symbols, spatial markers</i>	☐ Surface Modification <i>Surface alteration through embossing, puncturing, heat</i>	☐ Explanatory <i>Providing detailed descriptions or context</i>	☐ Linked <i>Positioned at a distance with a visual/tactile connector.</i>	☐ Collaborative <i>Shared within a group or co-creation, requiring common conventions</i>
	☐ Auditory <i>Spoken descriptions, voice notes, non-speech audio</i>	☐ Digital Overlay <i>Non-physical annotation through a technology layer</i>	☐ Highlighting & Emphasis <i>Drawing attention to significant elements</i>	☐ Layered <i>Separate physical or technological layers that can be accessed independently of the primary content</i>	☐ Instructional <i>Created by an educator for a learner</i>
	☐ Haptic <i>Vibrations, temperature changes, force feedback</i>		☐ Relational <i>Indicating connections between multiple elements</i>		☐ Professional <i>For broad distribution, prioritizing standards</i>

2.3 Analysis of Patterns and Challenges

By synthesizing insights from both academic literature and community practice, we observe several patterns in how tactile annotations are employed and the challenges that persist across contexts. These findings help reflect where existing approaches fall short, and where new design opportunities lie for tactile interaction techniques.

System-authored or user-authored. Most research studies that involve tactile annotations focus on pre-authored *system-generated* annotation content that is typically prepared beforehand by a professional researcher or designer, while only four studies involve *user-generated* annotations (Tab. 1). While visual annotation tools typically allow users to both create and modify their own marks, most tactile systems reviewed in this work position BLV users as consumers rather than authors of annotations. Even in user-generated cases like TacNote [18], the creation process requires specialized equipment and technical setup that may not be readily available in everyday contexts. In contrast, community practice places far more emphasis on user-created annotations.

This asymmetry extends to the temporal dimension of annotation. Traditional visual annotation supports iterative refinement where users can easily modify, delete, or reorganize their marks as their understanding evolves. However, many tactile techniques produce permanent modifications to physical materials. Once puff paint dries or a Braille label is affixed, revision becomes difficult. The current community tactile annotation techniques are deliberate user activities rather than a fluid, iterative thinking tool.

Precision and portability. Visual annotation systems excel at precise targeting, where users can annotate specific data points, draw precise boundaries, or highlight individual words. Tactile annotation faces inherent precision challenges due to the resolution limits of human touch and the physical properties of materials. Community practices work within these constraints by developing conventional spatial arrangements through placing audio stickers in consistent locations, using standardized symbol sizes, or adopting grid-based layouts that support systematic exploration. The literature shows various attempts to ensure the precision in tactile annotation, from the finger-tracking approach in *Markit and Talkit* [34] to the percussion-based system in *Tickers and Talker* [33], but these solutions may introduce complexity for everyday annotation tasks. These designs also typically utilize custom technical setups (9/12 studies) which are not designed for remote or portable use. These challenges also resonate with sociotechnical considerations identified by Lee and Lundgard [23], who note the tension between high-cost, high-resolution technologies and more accessible, low-tech alternatives. Without careful attention to these interconnected factors, technical solutions risk becoming inaccessible in practice.

Collaborative and shared understanding. Research systems tend to focus on personal use, with only a few studies (2/12 studies) that consider how tactile annotations might support group learning, shared exploration, or asynchronous feedback. However, the practical ecosystem of tactile materials creation is populated by a diverse

group of users with distinct roles, motivations, resources, and standards. Teachers of the visually impaired curate, adapt, and create tactile annotations for their classrooms, where immediacy and customization in prototyping are favored. Parents and family also create tactile annotations at home environments that support early literacy development through programs such as the *tactile experience books* [7]. Transcribers and tactile graphics specialists prioritize accuracy and standardization as they professionally create annotations as part of publishable and archival tactile materials. These distinct creator roles each operate with different goals, resources, and quality standards, resulting in a highly varied and often inconsistent landscape of tactile materials. In addition, unlike digital systems where annotations can be easily copied, modified, and distributed, physical tactile annotations require manual recreation for sharing. A teacher's carefully crafted tactile diagram cannot be easily replicated for multiple students or adapted for different learning objectives. Current practices rely heavily on person-to-person knowledge transfer rather than systematic, scalable approaches to collaborative annotation. This gap between bespoke, community-driven solutions and the need for scalable tools highlights the importance of understanding the full sociotechnical context, including the cost of materials, adherence to established standards, and the actual needs of the disability community [23].

3 TOWARD A FRAMEWORK FOR TACTILE ANNOTATION

The patterns identified in our analysis reveal that tactile annotation operates within a complex design space constrained by material properties, spatial limitations, and social dynamics that differ fundamentally from visual annotation systems. To support more systematic development of tactile annotation techniques and tools, we propose a descriptive framework (Tab. 2) that captures the essential dimensions along which designers and researchers can use to characterize, compare, and develop tactile annotation approaches. The detailed description of each element is included in the Appendix. Rather than prescribing optimal solutions, this framework serves as an analytical lens for understanding the trade-offs and opportunities within the tactile annotation design space.

4 CONCLUSION

In this paper, we surveyed the landscape of tactile annotation, drawing from both academic research and community practices to highlight current implementation and future innovation opportunities. We constructed a descriptive framework of critical attributes for tactile annotation to guide the development of more expressive, user-authored, and collaborative annotation systems. By shifting the focus from passive annotation access to active engagement, we can create more inclusive tools that empower BLV individuals to not just consume data, but to enter into a meaningful dialogue with it.

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