SymbolPath: A Continuous Motion Overlay Module for Icon-Based Assistive Communication

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ABSTRACT

Augmentative and alternative communication (AAC) systems are often used by individuals with severe speech impairments. Icon-based AAC systems typically present users with arrays of icons that are sequentially selected to construct utterances, which are then spoken aloud using text-to-speech (TTS) synthesis. For touch-screen devices, users must lift their finger or hand to select individual icons and avoid selecting multiple icons at once. Because many individuals with severe speech impairments have concomitant limb impairments, repetitive and precise movements can be slow and effortful. The current work aims to enhance message formulation ease and speed by using continuous motion icon selection rather than discrete input. SymbolPath is an overlay module that can be integrated with existing icon-based AAC systems to enable continuous motion icon selection. Message formulation using SymbolPath consists of drawing a continuous path through a set of desired icons. The system then determines the most likely subset of desired icons on that path and rearranges them to form a meaningful and grammatical sentence. In addition to demonstrating the SymbolPath module, we plan to present usability data and discuss iterative modifications to the software.

Categories and Subject Descriptors

H.5.2 [**User Interfaces**]: Graphical User Interfaces; K.4.2 [**Social Issues**]: Assistive Technologies for Persons with Disabilities

Keywords

AAC, Icons, Continuous Motion

1. MOTIVATION

Many individuals with speech impairments severe enough to preclude spoken communication also have accompanying limb impairments that must be considered when designing assistive communication interfaces [4, 3]. Icon-based AAC systems offer the potential for faster and less effortful message formulation compared to letter-based systems [6] and thus are often used by individuals with compromised motor function; however, manual methods of icon selection on current icon-based AAC devices require precise and discrete movements that hinder communication rate and ease. Additionally, the complex and repetitive nature of discrete movements can further contribute to fatigue. Several letter-based approaches to continuous selection have demonstrated commercial success (e.g. Swype, SlideIT, TouchPal, and ShapeWriter [2]), but no such approaches currently exist for word-based or icon-based formulation. This project aims to enhance message formulation ease and communication rate by combining continuous motion icon selection with a free-order language model.

ASSETS'12, October 22–24, 2012, Boulder, Colorado, USA.
ACM 978-1-4503-1321-6/12/10.

2. IMPLEMENTATION

SymbolPath is implemented in Python as an overlay module for traditional icon-based AAC systems. A simple single-layer array serves as the interface for the current work. The top row is dedicated to displaying the message being formulated and the remainder of the interface is arranged as a grid of candidate icons (Figure 1). Icons are grouped based on lexical roles: actors, verbs, objects, and modifers. Icon groups are color coded and arranged from left to right to mirror the subject-verb-object syntax in English. To formulate a message, users create a continuous path through a set of desired icons. To further reduce the physical demands of message formulation, the order of icons on the path is not constrained by syntax: users can select icons in close physical proximity rather than in syntactical order. The only requirement is that a continuous path be drawn through all desired items without breaking contact with the interface. During message formulation, the treaded path is displayed for feedback. Once the user breaks the path or enters the message formulation window, the language module attempts to concatenate a meaningful and syntactically accurate utterance from the set of selected icons. The text-to-speech synthesizer then voices the message. SymbolPath is compatible with any input modality that can provide a continuously varying analog signal such as a stylus, mouse, joystick, or laser pointer.

Two major issues need to be resolved in order to enable continuous motion icon selection: (1) superset pruning, because the user's path may include both target elements and bystander elements, and this superset must be pruned to yield the most likely desired candidates; and (2) syntactic reordering, because the user may have selected icons in an unordered way and the system must reorder those icons in the proper syntax of the target language.

Semantic disambiguation is required for situations in which removing or reordering words could dramatically alter the meaning of the potential message. SymbolPath relies on a combination of semantic frames, semantic grams, and phys-

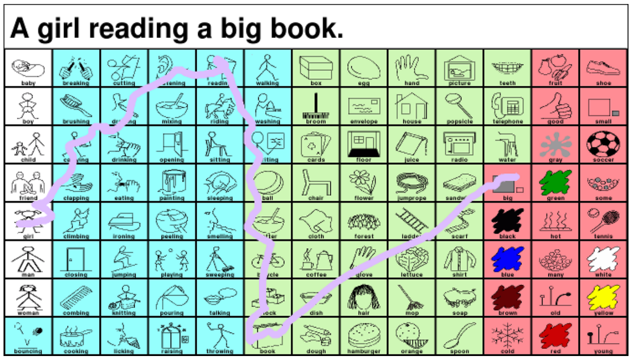

Figure 1: Sample message formulated using SymbolPath. The user creates a path as she traverses through the target (girl, reading, book, big) and intermediary icons (e.g. clapping, listening, bicycle), which are then pruned and reordered to generate a meaningful and syntactically complete message.

ical characteristics of the path to generate a prioritized list of potential utterances. Although the demonstration version automatically selects the most likely utterance to enhance communication speed, it can also display the list of potential utterances for user verification prior to speech generation.

2.1 Semantic Frames

Fundamental to the design and functionality of SymbolPath is the use of semantic frames [1], in which the predicate or verb of an utterance is the central element of a frame that can be filled by a set of relational items [5]. Thus, SymbolPath generates syntactically complete utterances by relying on the semantic frames of predicates in the selected path. Because each icon group is associated with a set of possible syntactic and semantic roles, the superset of selected icons is pruned by assessing subset probabilities within a given semantic frame. This approach provides a rudimentary solution to the issue of syntactic reordering, but does not address the issue of semantic disambiguation, especially with regard to assigning statistical values to potential utterances.

2.2 Semantic Grams

To prioritize the list of potential utterances, SymbolPath leverages prior work in the areas of subset completion and non-syntactic prediction [8]. Specifically, semantic grams, or sem-grams, are used to assign each potential utterance a value that corresponds to the probability of that combination of words appearing in a sentence together, regardless of order. Semantic ambiguity is not a concern because lexical roles are specified for each icon based on its grouping.

2.3 Path Characteristics

In addition to the probabilities of each potential utterance based on its semantic coherence, the physical characteristics of the path are also considered. Once the list of potential utterances has been prioritized semantically, the rankings are adjusted based on the two-dimensional collision space of the continuous motion path and each icon's surface area. Icons that collided with a larger area of the user's drawn path are assigned a greater likelihood than icons that were only marginally on the drawn path.

3. FUTURE DIRECTIONS

SymbolPath does not currently support complex utterances that contain multiple verbs (e.g. "I like to play baseball"), utterances that contain multiple actors and participants (e.g. "I like to play chess with my brother"), or utterances that make extensive use of modifiers (e.g. "I really drank that huge soda too quickly"). Although many of these situations can be supported through the use of semantic tagging, the current work aims to develop automated solutions to these problems. One potential approach is to supplement sem-gram statistics with corpus-based frame statistics in order to determine probabilities for each semantic frame and its arguments. While large corpora of AAC messages are unavailable, there have been recent efforts to simulate corpora that may be useful for obtaining such frame statistics [7]. Additionally, each user's message formulation history may be used to automatically refine the language model between sessions. Future work on SymbolPath may also include smoothing of the physical path to accommodate users with hand or arm tremors, as well as a calibration mode to detect each user's movement preferences and adjust the path's physical characteristics accordingly.

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