Tensai: A Sketch-based Educational Game for Assessing Proper Writing of Japanese Writing Scripts

Dakota Sloniger, Rupen Sakariya, Carlo De Guzman, Jacob Mathews *
Erwin Susanto, Jung In Koh, Paul Taele, Tracy Hammond †
Sketch Recognition Lab, Texas A&M University

**ABSTRACT**
Japanese foreign language educators encourage proper writing techniques to help students more effectively learn its writing component. Due to written Japanese’s complexity, educational games have tried to make its learning more engaging to reduce frustration. However, existing educational games lack either direct symbol writing input or more sophisticated proper writing assessment. We developed Tensai, a sketch-based educational game that provides an engaging way to practice and receive assessment on proper Japanese writing technique performance. Our game leverages sketch recognition techniques in a Japanese culturally-themed game, and includes time-based objectives to encourage playful and individualized learning of Japanese symbol writing. From our evaluations, we discovered that users generally found Tensai to be engaging and helpful for practicing their Japanese symbol writing.

**Index Terms:** Applied computing—Education—Computer-assisted instruction; Applied computing—Document management and text processing—Online handwriting recognition

1 MOTIVATION
Japanese as a foreign language is one of the most difficult global languages for native English speakers [3] to master, and can take three times longer to achieve equivalent fluency compared to a European language [5]. Written Japanese especially is “a labor-intensive endeavor” that requires English speakers to expend significant amounts of “time, patience, discipline, and perseverance” [5] to study its complex and diverse writing script symbols [9]. Educators often introduce stroke writing techniques (e.g., stroke order, direction, and count) for more effectively studying their respective writing scripts [10]. However, valuable personalized feedback of these pedagogical approaches from human language instructors may not be easily accessible outside of classroom hours or for larger classroom sizes [4].

Continuing advances in computer-assisted language learning tools via mobile apps provide one potential solution to complement existing classroom instruction, by leveraging writing assessment techniques and language gamification for written Japanese [6, 7]. Such tools allow students outside of the classroom to maintain emulated instructor assessment of their Japanese writing technique skill through an entertaining gameplay approach. However, existing educational tools are dominantly constrained by various factors such as lack of writing input (e.g., [1]), heavy scaffolding that does not accommodate natural writing [11], and minimal written technique assessment feedback (e.g., [2]).

We describe Tensai, an educational application that incorporates automated assessment of students’ proper Japanese writing performance into an engaging sketching game. Tensai adapts sketch recognition techniques for assessment and a Japanese culture-themed visualization to provide Japanese writing practice with real-time feedback. From our evaluations, users felt that Tensai was both engaging and useful for improving their Japanese writing.

**2 APPROACH**

2.1 Expert Interviews

We first recruited two Japanese language instructors—one female—at a large public university in the United States, in order to help guide the design of our proposed educational application. The instructors had at least five years of university teaching experience. From coding the responses of the individual half-hour semi-structured interviews, we discovered the following four key points: 1) writing Japanese correctly for the first time is important, 2) repetitious writing is important, 3) poor spacing in an individual symbol can look separated, and 4) incorrect stroke order and place can make characters look ambiguous.

2.2 User Interface

From the instructor interviews and review of existing educational applications, we created our game’s user interface (Figure 2).

- **Character Health Bar:** Visual indicator of number of available chances for unsuccessful writing attempts.
- **Character Actions:** View of user’s and computer’s black and red ninja characters, respectively. The computer throws a star with prompted symbol to write at the player to destroy or get hit by the star, depending on for writing input correctness.
- **Writing Controls:** Space to write and edit their symbols.

2.3 Recognition System

From the instructor interviews’ third key insight, our recognition system consists of a visual structure and a written technique assessor.

**Figure 1:** Tensai application on laptop and smartphone. **Figure 2:** Screenshot of Tensai’s in-game interface.

**Figure 3:** Different stroke visual cues for written technique error: (l) incorrect direction, (c) incorrect order, (r) extraneous stroke.
2.3.1 Visual structure assessment
Our visual structure assessor determines whether the written symbol matches the latest prompted symbol during gameplay, which was adapted from [8].

1. Collect expert’s template data of properly-written symbols.
2. Resample templates and input to 32 points.
3. Scale templates and input into a unit-sized bounding box.
4. Translate templates’ and input’s bounding boxes to the origin.
5. Calculate weighted Hausdorff distance between each template to input.
6. Select template with shortest Hausdorff distance to input. Assign template’s class to input.

Afterwards, the assessor checks whether the selected template’s class matches the class of the user’s input. If there is no match, then we can infer that they are not visually similar.

2.3.2 Written technique assessment
Our written technique assessor addresses the instructor interviews’ fourth key point by partly adapting techniques from [7] to assess incorrect stroke order, direction, and count.

- **Extraneous Count:** Spatially match template strokes to closest input strokes, then re-evaluate matching strokes for visual structure correctness. If visually correct, then extraneous strokes are highlighted. Highlight all strokes otherwise.
- **Insufficient Count:** Spatially match template strokes to closest input strokes, then display unmatched template strokes.
- **Incorrect Order:** Spatially match template strokes to closest input strokes, then temporally compare input stroke order after sorting them by their corresponding template strokes’ time, and finally notify of incorrect order.
- **Incorrect Direction:** For each input stroke spatially matched to unique template stroke, resample input and template stroke to same point count. Perform two calculations of summed point-by-point Euclidean distances between both resampled strokes, both in input’s original and reverse point order. If reverse order’s summed distances are smaller, then notify user of incorrect direction.

3 Results and Discussion
We recruited 20 university students—5 females—between 19 and 22 years of age, inclusively. Participants self-reported native English and no East Asian language fluency. We introduced to them a limited set of twelve representative symbols from Japanese’s writing scripts (Figure 4).

Participants were introduced to two aspects of our game: game mode and practice mode (an assessment interface with only writing and editing controls). We instructed each participant to perform three writing tasks: 1) continuously write each symbol in practice mode until input counted correct twice, 2) play one session for familiarization, and 3) play one session until game over or voluntary exit. Symbols were presented randomized, and all participants saw three writing tasks: 1) continuously write each symbol in practice mode until input counted correct twice, 2) play one session for familiarization, and 3) play one session until game over or voluntary exit. Symbols were presented randomized, and all participants saw.

From the responses, we believe that overall reception of the game was very positive. 17 of the participants found the app easy to use, with 15 of those saying they would use it frequently. 15 of the users found the game to be engaging. More importantly, 19 of the 20 participants felt they could improve their handwriting through use of the app. Lastly, 18 of the users considered the character recognition to be fair. We believe that our evaluation demonstrated Tensai’s potential as a character writing educational application for assisting novice students in effectively obtaining valuable feedback on their Japanese script writing performance.

4 Conclusion and Future Work
In this work, we describe Tensai, an educational game for practicing Japanese writing with intelligent assessment and engaging gameplay. We interviewed two Japanese language instructors for insights on our interface design and features, and developed a sketching game that provides written technique assessment on introductory Japanese writing symbols. From our evaluations, users felt that our system was engaging and has potential for improving their writing.

One potential areas for expanding our work includes providing variable challenges and objectives for users during writing practice, so that they may improve their Japanese writing proficiency. We are also interested in incorporating additional introductory Japanese script symbols for furthering students’ writing practice.

References