An On-Line Japanese Handwriting Recognition System integrated into an E-Learning Environment for Kanji

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Summary

In this work, a Japanese handwriting recognition system is being developed. The system is integrated into an e-learning environment in order to provide a Kanji teaching application with automated error correction. Conceptually, the application is an e-learning environment for Japanese characters, intended for the western learner of the Japanese language. Most e-learning systems of Japanese Kanji provide only a multiple choice method for the learner to reproduce characters. The present prototype offers the ability to enter characters with a stylus on a touch screen system.

The study seeks to determine to what extent it is possible to use modern NLP methods for language learning. While other studies mainly focus on grammatical correction, this application is targeted on the Kanji characters. It will be examined if a handwriting recognition engine can generate informed feedback, suitable for a learner. Additionally, the study examines if that feedback helps obtaining the ability to actively reproduce the Kanji characters.

The prototype developed in this work combines e-learning methods with natural language processing applied to the Japanese script. In order to prepare the task of creating an interdisciplinary software that spans across the aforementioned fields of study, the work reviews the structure of the Japanese script, the current state of the art in handwriting recognition methods and e-learning techniques. The recognition engine implements a structural approach to Kanji character identification. The recognition performs partial analysis of substructures and binds the recognised elements together to form a character. Because of the structural approach it becomes possible to create an informed error recognition that considers linguistic units of the Kanji characters.

The study resulted in the knowledge that it is indeed possible to use a handwriting recognition engine for the generation of informed feedback based on the errors made.

Zusammenfassung

In dieser Arbeit wird eine Handschriftenerkennung für japanische Kanji entwickelt. Der Handschriftenerkenner ist in eine E-Learning-Umgebung integriert und liefert eine automatisch generierte Fehlerkorrektur für Lernende.

Das System ist in konzeptioneller Hinsicht eine E-Learning-Anwendung für das Erlernen der japanischen Schrift. Letztere weist aufgrund ihrer morphemischen Struktur einen hohen Komplexitätsgrad auf und benötigt daher besonderen Lernaufwand. Die meisten E-Learning-Systeme für asiatische Schriftzeichen bieten Zeichenabfrage als Multiple-Choice an, da die Eingabe der Zeichen für einen Lernenden sonst ein technisches Problem darstellen würde. Der in dieser Arbeit erstellte Prototyp bietet die Möglichkeit zur handschriftlichen Eingabe von Zeichen auf einer dafür geeigneten Bildschirmoberfläche. Das ist ein Alleinstellungsmerkmal unter den E-Learning-Anwendungen für die japanische Sprache.

Die Studie untersucht, inwieweit es im Bereich des Schrifterwerbs möglich ist, NLP und Lernmethoden zusammenzubringen. Dabei wird nicht mit Parsing-Methoden die grammatische Struktur der Sprache untersucht, sondern vielmehr die interne Struktur der Kanji zugrunde gelegt und durch einen Handschriftenerkenner erfasst. Dabei sollen Schreibfehler strukturell erkannt werden. Intelligentes Feedback soll dem Lernenden dabei helfen, die Fähigkeit der aktiven Reproduktion der Kanji zu erwerben.

Da der Prototyp eine disziplinübergreifende Software ist, die in den Bereichen Handschriftenerkennung und E-Learning angesiedelt ist, wird in der vorliegenden Arbeit der Forschungsstand der beiden untersucht. Weiterhin wird die Struktur der japanischen Schrift linguistisch analysiert und dargestellt. Die Kombination der drei Disziplinen in einer Studie führt dazu, dass die Substrukturen der Kanji überhaupt programmatisch analysiert werden können, wodurch die Fehlererkennung ermöglicht wird.

Das Ergebnis der Studie zeigt, dass es möglich ist, eine Handschriftenerkennung nutzbar zu machen, um einem Lernenden intelligentes Feedback zu geben, basierend auf den Fehlern, die bei der Eingabe gemacht wurden.

Chapter 1

Conceptual Design of Kanji-Coach

1.1 Requirements of a Kanji Teaching E-Learning Application

1.1.1 General Considerations

In order to create a concept for a Kanji teaching application, a number of different aspects need to be taken into consideration. These aspects emerge from the academic background concerning the Japanese script, pedagogical and didactic knowledge about teaching languages and general conceptions of e-learning applications.

Many efforts in designing e-learning applications are focused around the teacher's view on learning. For designing an e-learning application that is useful to students, the students view needs be taken into account (Alexander and Golja 2007). Ivašin (2009) criticises the technical dominance in e-learning and e-teaching processes, as the conceptual software designs are not always supporting the didactic purpose of the software. Therefore, the user view should be taken into account when conceptually designing an e-learning application. The requirement of a *user-focused design* follows directly from this view.

For on-line e-learning, it is a known that readers only scan the textual information displayed. Therefore it is not useful to provide a user with large blocks of text, but rather with smaller chunks that encourage skimming over (Hamid 2001). It can be expected that the fact that an e-learning process happens on-line does not greatly affect the user behaviour. Therefore, the observations made for on-line e-learning can probably be applied to offline desktop application based e-learning. The requirement of *keeping textual information short and concise* derives from that observation.

If e-learning is considered as a learning method in higher education, *blended learning* seems to be the most suitable form of e-learning. Blended learning means combining classroom activities with e-learning methods (Hettinger 2008; Kahiigi et al. 2008). Language learning is not necessarily considered as higher education. In case of studying Japanese, with its specific difficulties in language and the script, language learning is taken to an intellectual level that is at least close to higher education. Thus, an e-learning application for any aspect of the Japanese language should not have the ambition of possessing the capability to *teach Japanese*. Japanese is a complex language with a complex script. E-learning applications should aim at supporting a learner's classroom efforts of studying the language. The requirement of *focusing on a specific language aspect* can be drawn from this reasoning. The prototype system designed in this work does not aim at being a complete e-learning system, but rather offers individual learning components from which a user can choose what type of learning and which component best supports his study.

1.1.2 Conceptual Considerations for E-Learning of Kanji

An e-learning application for Kanji should be an e-learning application for vocabulary at the same time. It is conceptually not useful to split those two learning tasks (Stahlmann 2004). Learning Kanji and Hànzì is a visual task. Learners need to focus on many little details concerning a character. For example, the character 曜 contains 18 strokes that are difficult to distinguish from each other in a regular script size of 11pt. It is those details that make it difficult for a learner to remember a character. Thus, it is important to direct and guide the learner's perception and comprehension of the characters towards a construct of Radicals, rather than a combination of a large number of strokes (Stahlmann 2004). When attempting to split characters into conceptual sub units for the ease of a learner, three different approaches lend themselves to this goal.

Firstly, splitting the characters into certain strokes. There are 26 original strokes in the writing system and each shape in all the characters can be drawn with a combination of those strokes (Foljanty 1984). This approach does not seem to ease the task of memorising the Kanji. It may be fairly easy to memorise 26 strokes, but the fact that around 2,000 Kanji necessary for reading Japanese consist of these strokes, does not imply that memorising those becomes any less difficult.

Secondly, splitting the characters into graphemes. There are several shapes in use in the Japanese and Chinese writing system. There are 79 graphemes in use (Hadamitzky 1995). Using graphemes as a conceptual unit for a learner seems much more useful than employing the strokes as a direct sub unit of the Kanji. Memorising all the graphemes may help a learner to study the Kanji, because all sub shapes of the characters are known. However, graphemes do not necessarily bear a meaning. Seen from a perspective of perception and cognition, the coherence between the different parts of a Kanji would be purely visual. That can help learners with an outstanding visual memory, but probably not the majority with an average visual memory.

Thirdly, splitting the characters into Radicals. Radicals are the conceptual sub units of Kanji characters and they bear a meaning of their own. The number of Radicals is larger than the number of graphemes, but not all Radicals are in use and some graphemes are Radicals themselves at the same time (Hadamitzky 1995). The Radicals do not only bear a meaning, but also have a function in character formation (see section **??** for typology of the Kanji). In order for a learner to memorise the Kanji, it seems useful to grasp the concept of Kanji typology and therefore character formation. Equipped with the rules of character formation and a number of Radicals the brain can link different parts of a Kanji character with other parts and other characters. For example when studying phonograms, the majority of the Kanji characters, knowledge about the pronunciation of the phonetic Radical will help the learner.

Among those three possibilities it seems most suitable to use a combination of the second and the third. Conceptually, the characters will be split into Radicals, but the system must know about the concept of a grapheme, too. Ideally, the system would have data that distinguishes both.

1.1.3 Classification of a Kanji Teaching Application

1.1.3.1 Classification in an E-Learning Context

Different types of e-learning systems have been discussed in section **??**. In the course of designing a prototype system, design choices need to be made. The design choice for the prototype will be an offline e-learning system that runs on a desktop PC. This design choice does not follow a conceptual requirement, in fact it ignores Ivašin's (2009) criticism of technical dominance in e-learning systems. The choice is a purely technical choice, yet, it is driven by a conceptual requirement. The purpose of the e-learning environment is to test to what extend a handwriting recognition engine can help studying the Kanji. In order to examine that research question, the handwriting recognition needs to be implemented and integrated with the e-learning system. Thus, the design choice for an offline system was inevitable in the sense that the technical limitations of on-line applications form an obstacle for pen input of characters and fast recognition procedures.

According to the definition given by (Richert 2007) the Kanji teacher prototype is a *computer based training* (CBT) system, as it does not use the Internet for communication or a web server for storage. According to her research, another criterion for an identifying offline systems is that they are offered for distribution on CD-ROM or floppy disk. That criterion can be regarded as obsolete, as it refers to specific storage media. Even if a higher level of abstraction is used to describe the criterion, it is still obsolete, since *a passive storage medium* is not necessary to describe what the criterion actually tries to define. The criteria concerning communication and data storage are useful to confine different types of e-learning applications. Additionally, *installability* can be used as a criterion for offline e-learning systems. *Installability* here refers to *the possibility to install a software on a computer system*, not the *ease of installation*, which is defined in ISO9126 as *installability* as well (Chua and Dyson 2004). The ISO9126 type of installability will be taken into account during the software evaluation, which is reported in chapter **??**.
The levels of interactivity as described in section **??**:

1. **View and absorb objects**
2. **View and absorb multiple displays**
3. **Varying the form of representation**
4. **Changing the content of a component - parameter or data variation**
5. **Generating objects or the content of a representation**
6. **Constructive and manipulative actions through situation-dependent feedback**

The prototype designed in this work is aimed at a level higher than level *(**??**) Changing the content of a component*. It is targeted between the levels *(**??**) Generating objects or the content of a representation* and *(**??**) Constructive and manipulative actions through situation-dependent feedback*. Concretely, a user can:

- Change the ideal shape of a character by storing a new gold standard.
- Create new characters and their descriptions

- Receive situation-dependent feedback even on the newly created characters, due to the nature of the error recognition algorithm that evaluates mathematically the distance between a gold standard character and a an input. Additionally, characters are analysed structurally, therefore new characters added by the user will automatically be classified and arranged among the other characters in the database of the system.

Thus, based on the levels of interactivity (Richert 2007), it can be concluded that the prototype provides a very high level of interaction. The levels serve as an evaluation measurement for the quality of e-learning applications.

1.1.3.2 Classification of Kanji Coach Among Kanji Teaching Applications

Kanji Coach is an e-learning system for Kanji characters. Its unique features are

- The internal handwriting recognition engine
- The error recognition performed by the handwriting recognition module

The conceptual use of the handwriting recognition engine is dealt with in section 1.3. The error handling concept is presented in section 1.4.

There are several e-learning systems that are centred around learning to read and write Japanese:

1. **JWPce**: `http://www.physics.ucla.edu/~grosenth/jwpce.html`
   Special text processing editor for Japanese as a foreign language, including dictionaries.
2. **JFC**: `http://www.physics.ucla.edu/~grosenth/jfc.html`
   Application for learning Kanji.
3. **JapAlpha**: `http://members.aol.com/JapAlpha/private/japa10.htm`
   Application for learning the phonetic letters of Japanese.
4. **Hiragana und Katakana online lernen**: `http://www.theiling.de/schrift/#kanatop`
   Web site for studying Hiragana and Katakana.
5. **Moji**: `http://moji.mozdev.org/`
   Web browser extension for immediate dictionary lookup of Kanji.
6. **KanjiQuick**: `http://www.kanji.de/`
   Dictionary for Kanji-German with a translation module and a text to speech module.
7. **Kanji Gold**: `http://web.uvic.ca/kanji-gold/`
   E-Learning application for studying Kanji.
8. **KanjiGym Light**: `http://www.kanjigym.de/`
   E-Learning application for studying Kanji with the Heisig system.[1]
9. **Tagaini vocabulary teacher**: `http://www.tagaini.net/`
   Vocabulary teacher for Japanese.
10. **Online vocabulary teacher**: `http://www.vokabeltrainer-online.net/`
    General vocabulary teacher for several languages including Japanese.
11. **Kanji Teacher of SZSB**: `http://szsbls3.szsb.uni-saarland.de/kanji/`
    Online e-learning application for studying Kanji.
12. **Skritter**: `http://www.skritter.com`
    Online e-learning application for studying Kanji including a handwriting input.

Among the various e-learning applications centred around Japanese there are three different types of applications.

1. **Dictionaries**. In the dictionary type of applications it is possible to look up a Kanji and receive a translation in a different language, mostly English, sometimes German. Among those JWPCE is the most developed in the sense that it provides a Radical lookup. A user can choose a number of Radicals in a matrix of Radicals and the dictionary finds appropriate characters.
2. **Vocabulary teachers**. Vocabulary teaching applications provide interfaces for word look-up and foreign word input with either Unicode input or Latin transcription of Japanese words.

[1] The Heisig system is a method for studying Kanji, discussed in section **??**.

3. **Script teachers**. Script teaching applications are designed as two different types. Multiple choice applications and handwriting input.

    - **Multiple choice**. The large majority of e-learning applications teaching the Japanese script (either the two types of Kana or the Kanji) have to use multiple choice for character input. The reason for that is that modern Input Method Editors (IME) allow for a Latin input of Japanese words and provide the Kanji for the user. If the application would prompt the user with a task like *What Kanji is pronounced 'inu'?* the user would have to type 'I-N-U' in order to be presented with the character 犬 by the IME. In other words there is no cognitive task for the user except reading Latin characters from the screen and typing them on the computer keyboard. Since that does not help with the task of learning the Kanji, the only chance is multiple choice. The user is presented a set of characters and is asked to click on the one that had been asked for.
    - **Handwriting input**. There are only two applications that use a handwriting input method in order to teach the Kanji. However, none of the applications performs a handwriting recognition. Those two applications are *Skritter* and *KanjiGym Light*.

Skritter uses a kind of stroke-based similarity measure for individual strokes. When the system prompts the user for a specific character, it allows only the next correct stroke of that character as user input. Concretely, the user can just try to write any stroke. If it is close enough to the next correct stroke, it will be morphed into an idealised picture of that stroke. If not, Skritter will show the correct stroke. The system is clearly not a handwriting recognition system.
Figures:

- Figure 1.1 shows that Skritter does not allow any incorrect input by the user. If the user tries to input an incorrect stroke the correct stroke is shown on the screen. That feature avoids any learning from one's own errors, because the correct stroke is always given.
- Figure 1.2 shows the way Skritter morphs a user input to the correct position. The stroke length is adapted to fit the character. The user's error concerning the stroke length disappears immediately without any comment by the system. The system only comments incorrect stroke direction.
- Figure 1.3 shows the high tolerance that Skritter allows when morphing. The user input stroke has the correct shape and the right direction, but the euclidean distance of the input stroke and the ideal stroke is large. Nevertheless Skritter accepts that stroke as a correct input without a comment or feedback to the user.

KanjiGym Light does not perform a handwriting recognition. The application provides a canvas for writing characters. The user can input a character and then click a button named *check*. The correct character appears next to the user input and leaves it to the user to compare for correctness. There is an accept and a discard button.

- Figure 1.4 shows the user input canvas in KanjiGym Light.
- Figure 1.5 shows the way KanjiGym Light has the user compare his own input with the original character.

1.2 Approaching the Specific Difficulties of the Japanese Script

Section **??** deals with the typical problems that learners face when studying the Kanji. The Japanese script inevitably bears some difficulties when attempting to study it. The application should care for these problems by supporting these issues. They can be approached by providing not only a handwriting input for the user but also a handwriting recognition engine that gives informed feedback to the user.

1.2.1 Character Learning Aspects

The specific problems mentioned in section **??** are:

1. **Similar Kanji**
2. **Compounds**
3. **Unusual readings**

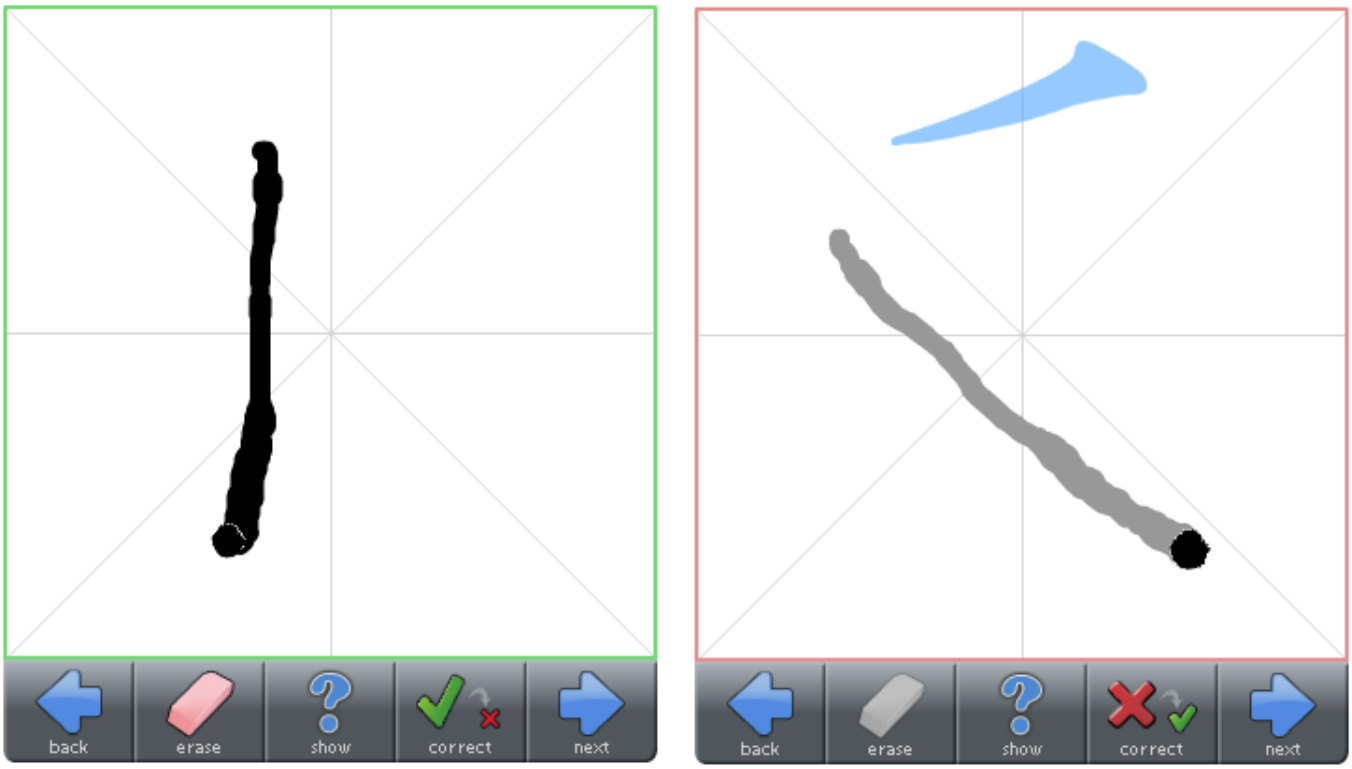

Figure 1.1: Skritter does not allow incorrect input

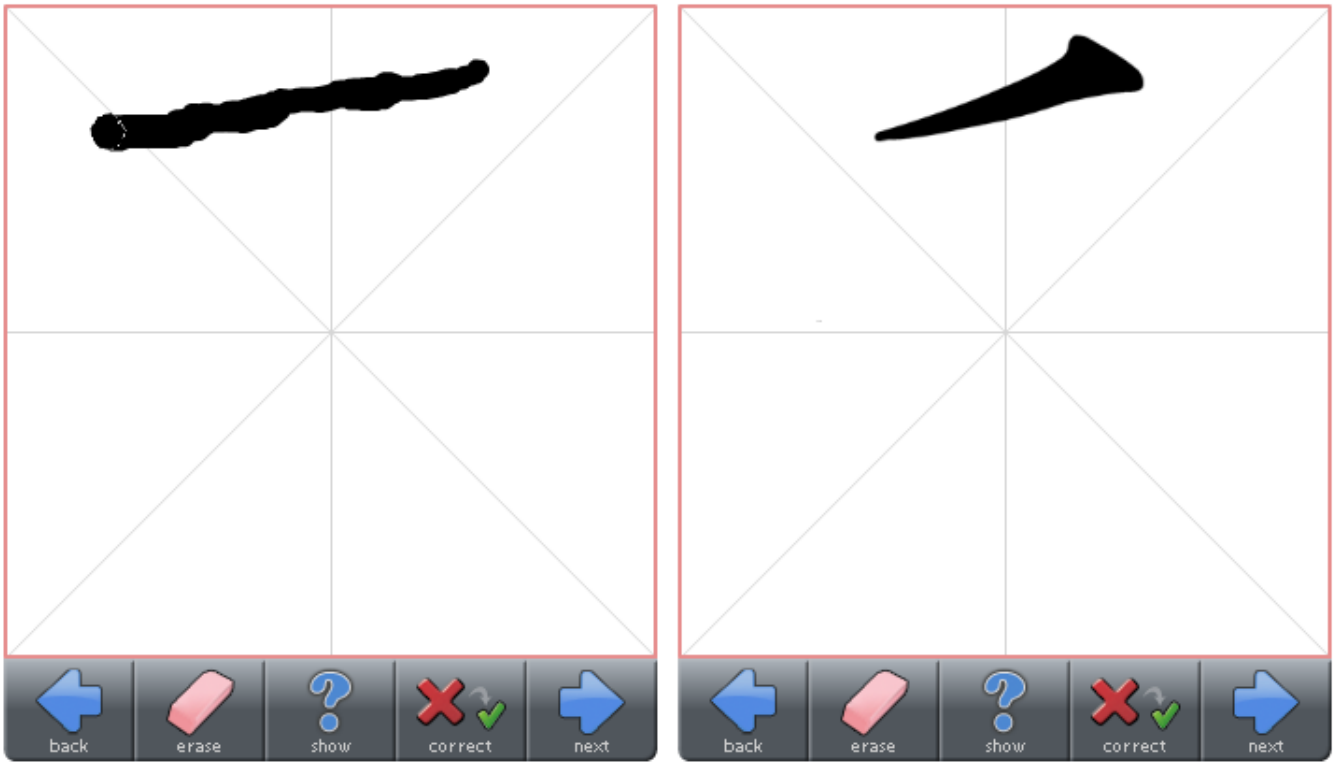

Figure 1.2: Skritter morphs user input to correct strokes

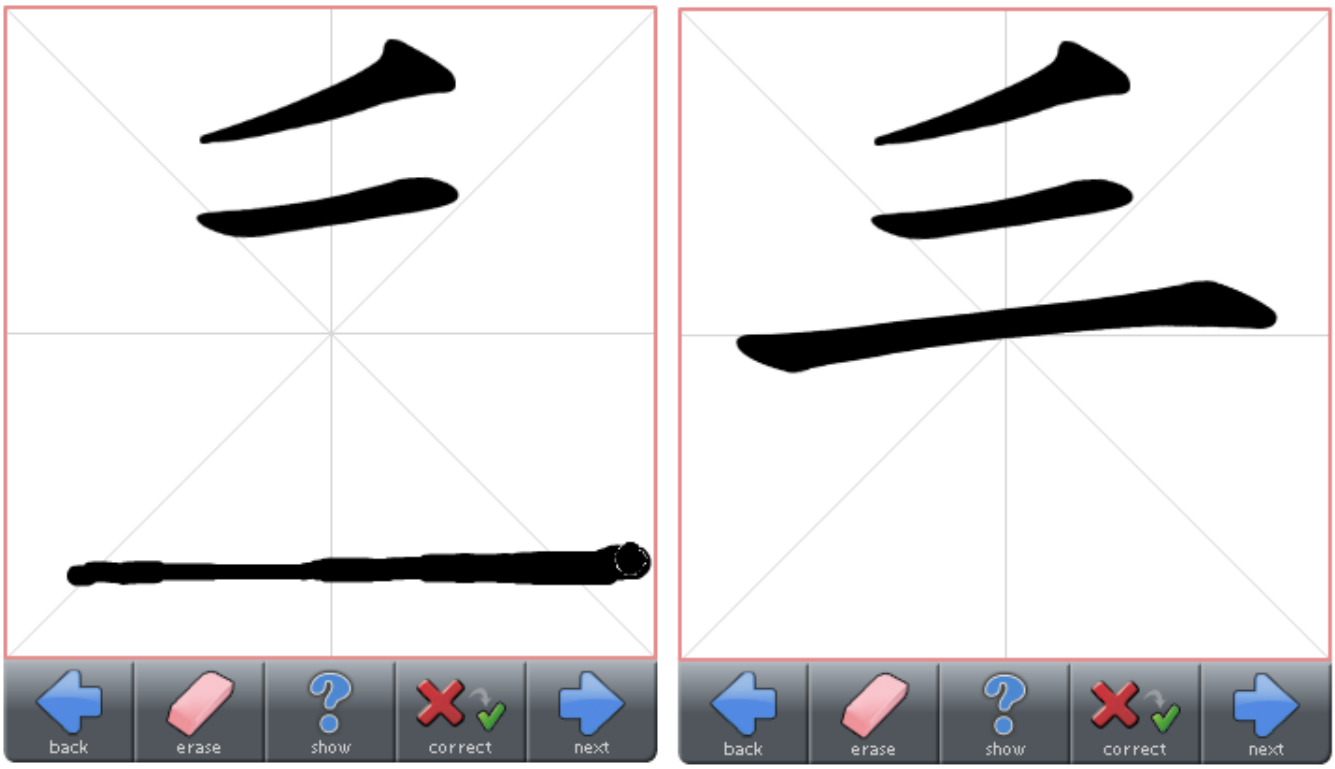

Figure 1.3: Skritter employs a very high tolerance when morphing user input

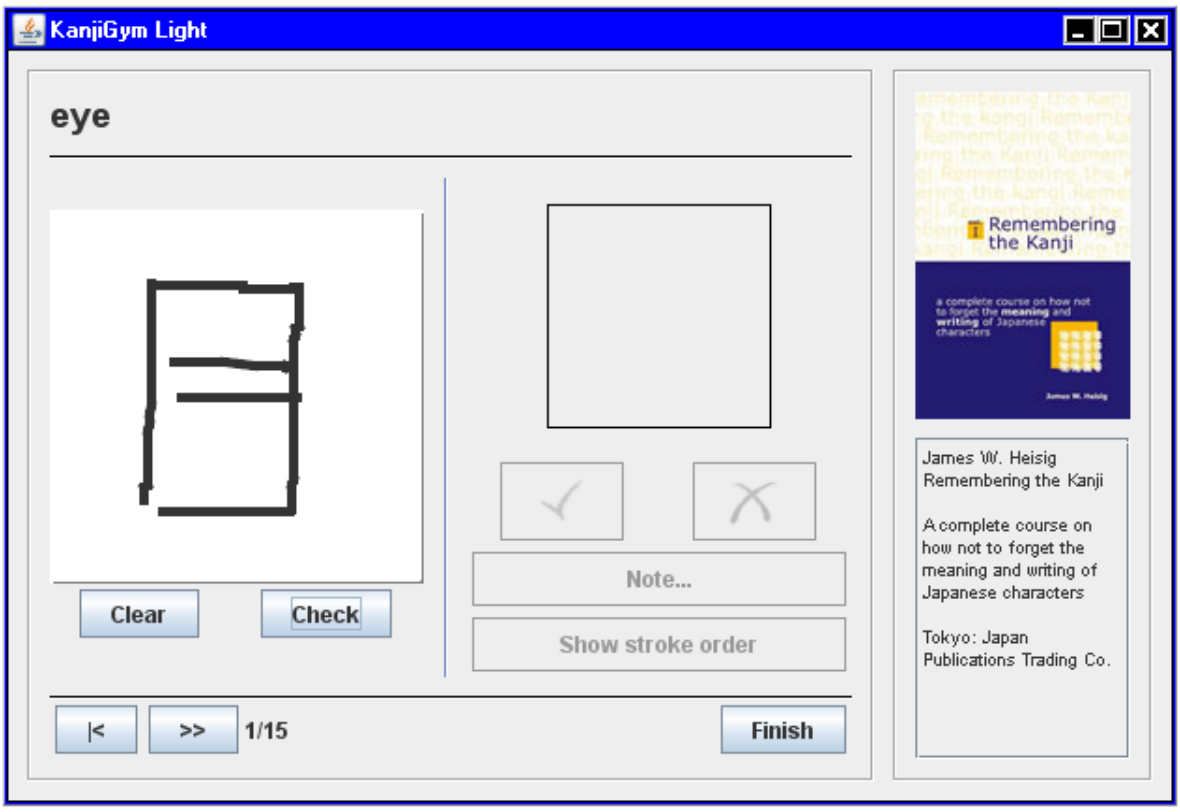

Figure 1.4: KanjiGym Light character input

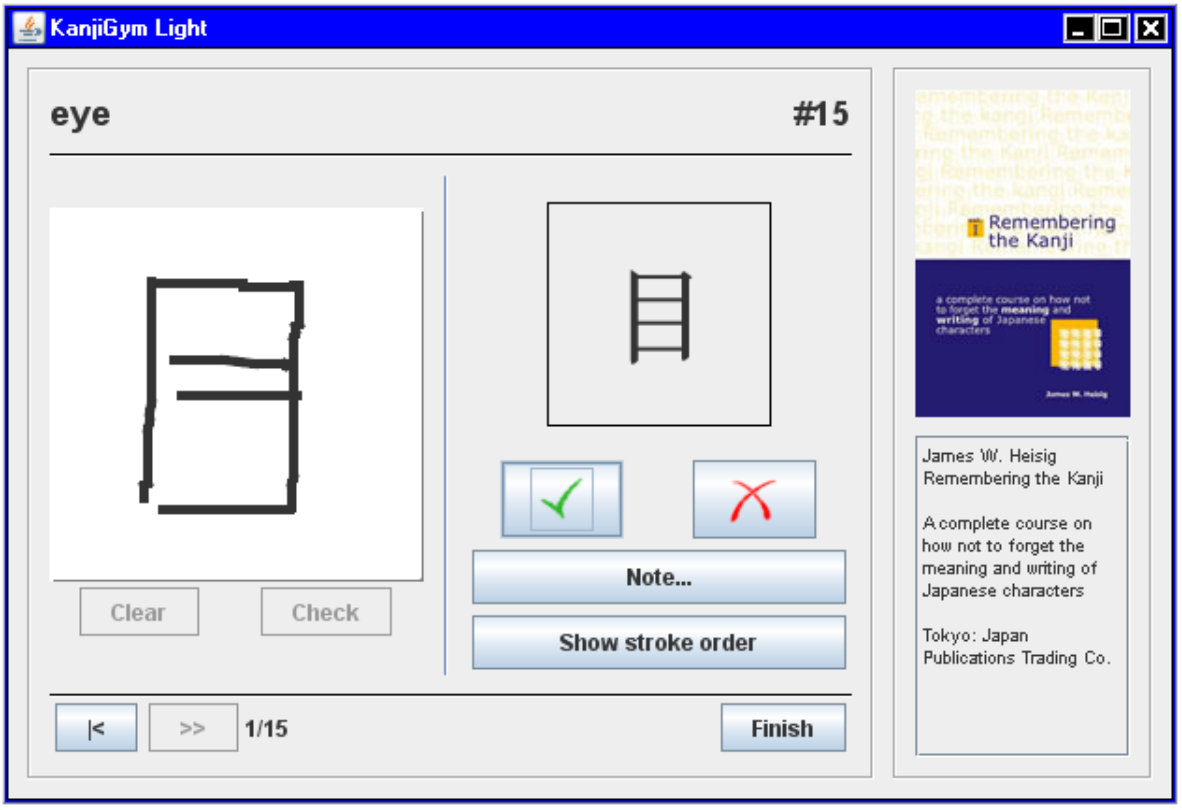

Figure 1.5: KanjiGym Light checking correctness manually

4. **Alternative Kanji**
5. **Homophones**
6. **Infrequent Jōyō Kanji**
7. **Non-Jōyō Kanji**

1.2.1.1 Problems Outside the Scope of the Prototype

A Kanji teaching prototype cannot provide solutions for all of those problems, but for some. It cannot provide a satisfying solution for problem 2 as the prototype deals with single characters only. It is not useful to provide a solution for problem 3 because studying the main reading of a character is most important at the beginning of studying Kanji. Especially, when studying a new character, the learner should focus on the character shape and the main reading, not on unusual alternative readings. Kanji Coach aims at teaching the Japanese script, not the full Japanese language.

Kanji Coach cannot provide a solution for problems 6 and 7, memorising infrequent Jōyō Kanji and Non-Jōyō Kanji. These characters are difficult because they are infrequent. It seems more suitable for a learner to study the frequent characters first in order to learn reading and writing. Thus, it is not plausible to pay special attention to this group of characters by presenting those more often to the learner.

1.2.1.2 Problems Inside the Scope of the Prototype

The two main problems for learners of Japanese Kanji are

- Similar Kanji (problem 1)
- Homophones (problem 5)

Those two will be dealt with in the prototype. Additionally, the problem of

- Alternative Kanji (problem 4)

is targeted by the e-learning application.

Similar Kanji are the major issue for a learner of Japanese. The prototype *Kanji Coach* provides a solution for this difficulty. The solution does not necessarily contain the employment of specialised lessons for similar-looking Kanji. The reason for that is that it is more suitable for the human brain to study material that belongs to the same range of topics. Similar looking Kanji often do not have a connection to each other except their visual similarity. Therefore, studying them together does not seem useful, unless they are semantically similar, too, like for instance the characters for *speaking* 話, *state/give instructions* 誥 and *language* 語 that also belong to the same Kanji class, as their key Radical is the same.

Homophones are a general difficulty for learners of the Japanese language. Many words are phonetically ambiguous. The context can provide a better understanding, but often it is necessary to see the written Kanji character in order to know what is meant with an expression (Foljanty 1984). Therefore, it is essential to deal with problem 5.

Conceptually, this issue can be solved by providing special lessons that focus on homophones. Homophones in Japanese are not necessarily homographs and therefore not homonyms in the strict sense. True homonyms are those word pairs that are both homophones and homographs. In languages using Latin characters, homophones are often homographs at the same time, e.g. German *Schloss* (Eng. castle) and *Schloss* (Eng. lock). This is due to the fact that the spelling roughly mimics the speech. The pairs that are both homophones and homographs are called homonyms. Sometimes, homophones are not homographs, e.g. the verbs *dye* and *die*.

In the course of studying the Kanji, it is part of the study process to learn to distinguish the characters that are pronounced the same. For instance, there are roughly 80 distinct characters that share the pronunciation *kyo*. Table **??** on page **??** shows several Kanji that are pronounced *ki*. The prototype provides a lesson that is centred around the homophone Kanji characters and their distinction.

Alternative Kanji is an issue that can be dealt with in an indirect way. Following the concept that frequent characters and the main reading should be studied first, Kanji Coach does not provide any special form of presentation for this group of characters. However, it has the ability to recognise alternative Kanji. In a scenario where a user is asked to input a certain character, an alternative character with the same meaning would be accepted. For instance, if a user is prompted for the character for the number *one*, which is usually written as 一, but enters the character 壱 instead this input would be regarded as correct. Additionally, the user is presented with a hint that another character with the same meaning exits. The focus lies on studying the frequent characters, therefore there are no special lessons concerning alternative Kanji.

1.2.1.3 Character Repetition

In section **??** the pure repetition of grammatical structures as a learning method has been criticised. The system should account for that by not just forcing the user to reproduce fixed structures. In fact, it should leave room for creativity. The system does not provide a free-drawing module in order to allow for total creativity. But creativity is given through the use of the handwriting input as such. A user can practise his own writing style. The tolerance thresholds given by the character recognition module allow for an interpretation of the character shape, rather than a pure repetition.

Similar to the multi-radical look-up in JWPCE a learning task for a user of the Kanji e-learning prototype *Kanji Coach* could be the combination of different radicals to a Kanji character. That would allow for creativity and also appeal to the cognition because it is more demanding than merely repeating the shapes that were given before.

1.3 Integration of HWR Into the Learning Process

The learning process of Kanji is driven by understanding the structure and meaning of the characters and memorising the shape (Stahlmann 2004). In order to study and memorise, many learners rely on repeating to write the Kanji. That approach seems most natural and can hardly be replaced by any other method. Nevertheless, the method can be changed to be more challenging to a user and thus create some level of excitement. This is done by combining it with different tasks where the user does not see the character before having to write it.

1.3.1 The Motivation for Using a HWR

The fact that learning to read and learning to write are highly interwoven processes suggests that both should be studied together. In standard class room learning environments that is the case. Learners read texts, learners are presented with new Kanji and learners are asked to reproduce the Kanji when writing essays. An e-learning application can not perform the teaching effort of a full language course. In order to provide a complementary

addition to a language course, the prototype should create an environment that increases the user's regalement for tedious learning tasks.

The repetition of writing characters in order to memorise them does not appeal to the majority of the learners. Especially having to write on paper repeating the same character over and over again does not awake inspiration and creativity. An e-learning application with an integrated handwriting recognition engine that provides corrections for the user input has two main functions:

- Making the repetitive task of training the muscular memory less tedious.
- Helping the learner overcome difficulties in writing the Kanji by giving informed feedback.

In order to train the muscular memory and memorise the Kanji, repetition is needed. The same amount of written characters can seem less repeating simply if the characters are not written in a row. Additionally, using a technical device can be more emotive and help increasing the user's motivation and self-discipline. (Ismail 2002; Richert 2007) criticised that some e-learning applications do not add a value to the learning process.[2] The prototype proposed in this work does add value to the learning process. Additional value over practising to write characters on paper is added by the following features:

- The general ability of the application to prompt the user with different characters in an ordered or random fashion.
- Presentation new characters, their meanings, pronunciation and stroke order.
- Characters are organised in lessons and related characters are presented in combination with each other in the same lesson.
- The methods
  - Writing a Japanese character after being prompted an English word, instead of purely drawing lines without an additional cognitive anchor.
  - Writing a Japanese character after being prompted a Japanese word.
- The error correction that comes with the handwriting recognition. The user is less dependent on a teacher and can study in his own time and pace, yet still get informed feedback.

1.3.2 Character Recognition

The type of character recognition is crucial for the abilities of the system concerning error processing. Highly optimised handwriting recognition systems perform a fast and reliable handwriting recognition. However, those systems often do not have a record of the internal structure of the characters.[3] Since understanding of the structure of the characters is important for a successful learning process, the error correction needs to focus on the internal structure of the Kanji characters. Studying the character shapes can be performed as a purely visual task. Studying the full characters and grasping their construction is a cognitive task that combines visual memory with linguistic information. Thus, the error correction must provide structural error levels, considering the internal character structure. Following that concept even further, the character analysis must be structural as well. The prototype performs a structural character recognition.[4] Structural character recognition means that it performs a structural analysis of the characters in order to obtain a symbolic value for the character, in this case a unicode value.

1.4 Handling Errors

Having a handwriting recognition that gives informed feedback about the question if the entered character was correct is an approach that allows for additional analysis and feedback. Because of the structural analysis of the characters during the recognition process it becomes possible to provide feedback about errors on a graphemic, phonetic and semantic level.

[2] For details see section **??**.
[3] See chapter **??** for details.
[4] Details about how the character recognition is performed on a technical level can be found in chapter **??**.

1.4.1 Motivation for Error Recognition

The motivation for error recognition has been broached in the previous sections. The main reason is that a user needs be given a chance to learn from his own errors. In any relation between a student and a teacher, concerning any subject matter the teacher has the task to inform the student about mistakes. The teacher provides corrections to the errors of the student when trying to fulfil a task. The student can learn by improving what he had done wrong before.

For an e-learning application it is difficult to provide an informed error correction. The reasons for that lie in:

- The limitations of communication between the machine and the user: in the most common scenario the user interaction is limited to typing with the keyboard and clicking with the mouse
- The limitations of user input analysis. For text strings most of the times only exact matches are accepted. Some types of analyses are very difficult to perform, including syntax analysis and handwriting input. That is the reason for most interfaces to perform a simplified or a partial analysis of the user input or no analysis at all.
- Limited knowledge within the application about potential user errors.

In Kanji Coach these limitations shall be weakened. The communication between machine and user is dome with an Intelligent User Interface, a canvas that takes handwritten characters as input. The limited user input analysis is approached with the interpretation of the strokes as a Kanji character. Knowledge about possible sources of error is stored in the application's knowledge base, such that the third limitation has a less severe impact into user experience.

1.4.2 Possible Sources of Error When Writing Japanese Characters

There are seven different sources of errors for learners when writing Kanji characters. These error categories are:

- Stroke level errors
- Radical level errors
- Character level errors
- Linguistic level errors
  - Phonological errors
  - Morphological errors
  - Semantic errors
  - Lexical errors

Stroke level errors

- **Stroke length**: A stroke has been drawn by the user with an incorrect length.
- **Stroke direction**: The stroke has been drawn from the opposite direction or the general stroke direction, the absolute angle with respect to the X-axis was deviant.
- **Stroke angle**: If the stroke has a corner the angle of in the corner can deviate from the angle of the original stroke.

Radical level errors

- **Stroke number**: The number of strokes in the Radical is different from the number of strokes in the gold standard Radical.
- **Stroke sequence**: The sequence of strokes within the Radical is different from the ideal stroke sequence.

Character level errors

- **Incorrect Radical**: A Radical used within the character is not correct as it was confused with a different one by the user.
- **Incorrect number of Radicals**: An additional Radical has been added to the character or a Radical is missing.

Linguistic level errors are a super-category of other error category. The errors on a linguistic level do not concern the character input directly but rather the language and the use of the characters. The linguistic errors can be subdivided into phonological, morphological, semantic and lexical errors, where the latter ones have only a subtle distinction.

Phonological errors are errors concerning Kanji readings. If a user writes a character with the same reading as the character in question it is likely to be a confusion based on the phonological features of the two characters. The Japanese language has a large number of homophones that abet this type of confusion.

Morphological errors are mainly concerned with suffixation. If a Kanji character and additional Hiragana characters in order to form a word, these Hiragana characters are called *Okurigana*.[5] The error of adding incorrect Okurigana to a Kanji character can be classified as a morphological error. As the Kanji Coach prototype deals with single characters only this error type is not applicable.

Semantic errors are those errors where a user confuses two characters with a similar meaning. For example, the words 食べ物 (Jap. pron. タベモノ / tabemono; Eng. lit. *thing for eating*; Eng. *food*) and 飲み物 (Jap. pron. ノミモノ / nomimono; Eng. lit. *thing for drinking*; Eng. *drink*) can be confused easily on a semantic level. The same is true for the individual characters.

Lexical errors are the errors where a user uses a character with the same meaning. Those are not real errors. This falls under *alternative Kanji* that have been discussed in section 1.2.1.2. This type of error can be compared to using a synonym in a vocabulary test. The word was not the word asked but the answer is not incorrect either. Therefore, lexical errors do not need special attention the the prototype application.

1.5 Use Cases

The uses cases presented in this section are oriented towards the conceptual design presented in the previous chapters. The startup screen of the application is presented in figure 1.6. There are four different modes to choose from.

1. View mode
2. Follow mode
3. Exercise mode 1
4. Exercises mode 2

The user can employ different modes for self-directed study. In view mode, the characters and information about those are just presented to the user.

Figure 1.7 shows the view mode. On the left side of the screen the character is presented to the user. On the right side of the screen information about the character are displayed.

The first interactive character learning mode is the follow mode shown in figure 1.8. In follow mode, a character is shown and the user can follow the character lines that are shown on the screen.

The input in follow mode or in the other modes can be drawn on the mobile input area. That guarantees the ability to use a stylus. Figure 1.9 shows a drawing on the mobile device. In exercise mode 1 the user is presented an English word and is asked to draw the appropriate Kanji character. Exercise mode 2 works the same way, just the user is presented the Japanese reading of a character instead of the English word.

Figure 1.10 shows the screen of exercise mode 1 with a user input. The user input is mirrored from the mobile device as shown in figure 1.9 before. After the character recognition and error detection is performed, the application can return an analysis to the user. In this case the input was not quite correct. As seen in figure 1.8 in order to write the character for 'root', which is written 本, there is one stroke missing in figure 1.9 and the mirrored image in figure 1.10.

Incorrect stroke number is one of the errors defined in section 1.4.2. It is in the *Radical error level* as there is a stroke missing in order to finish the Radical. There is no error in character level. In this special case the character is a Radical. The error 'missing stroke' is relevant to the Radical level.

Figure 1.11 shows the error message and the feedback for the user. A missing stroke is just a minor error, therefore the user is presented a positive feedback.

[5] For a detailed description of what Okurigana are, see section **??**.

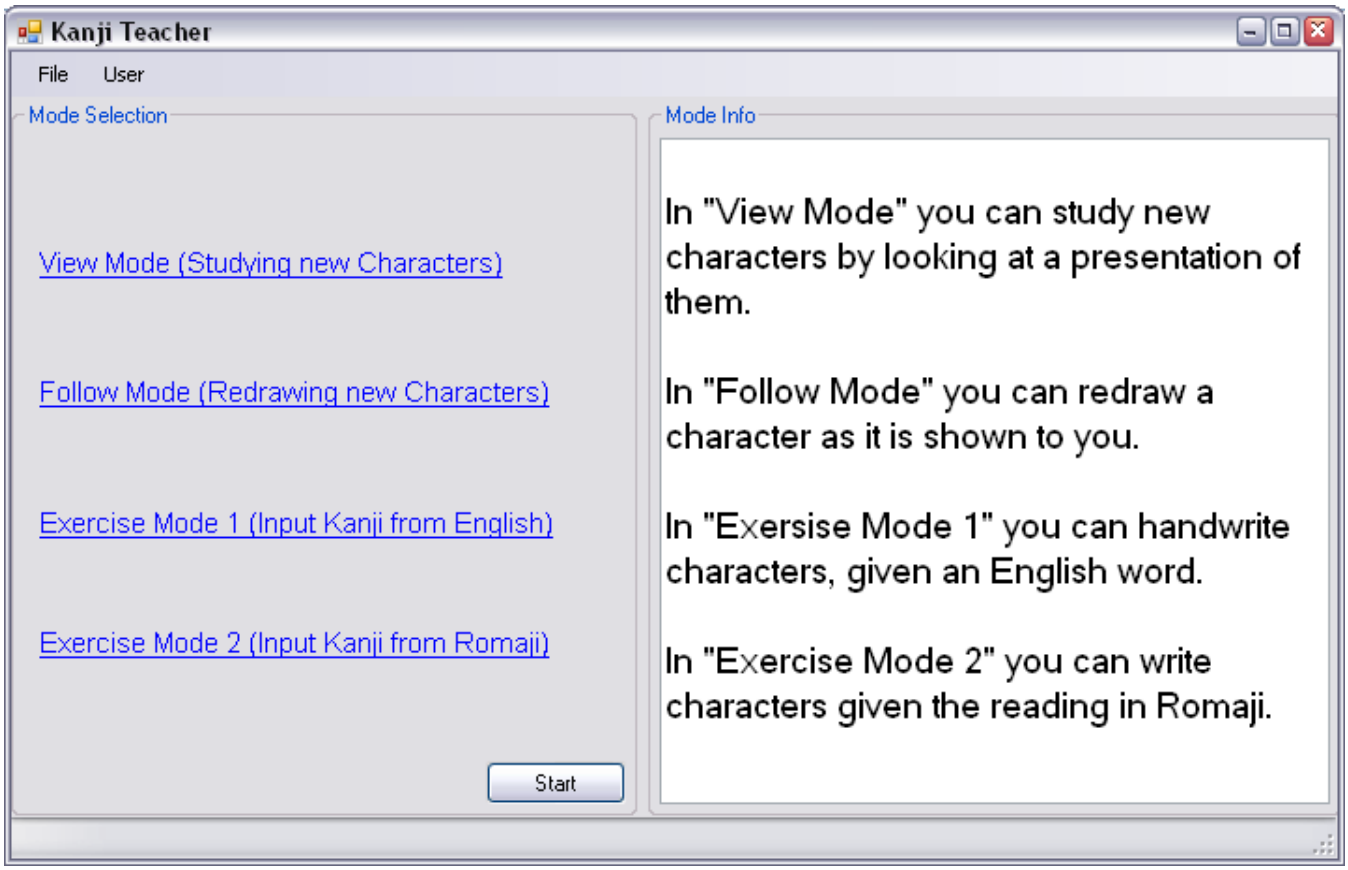

Figure 1.6: Startup screen

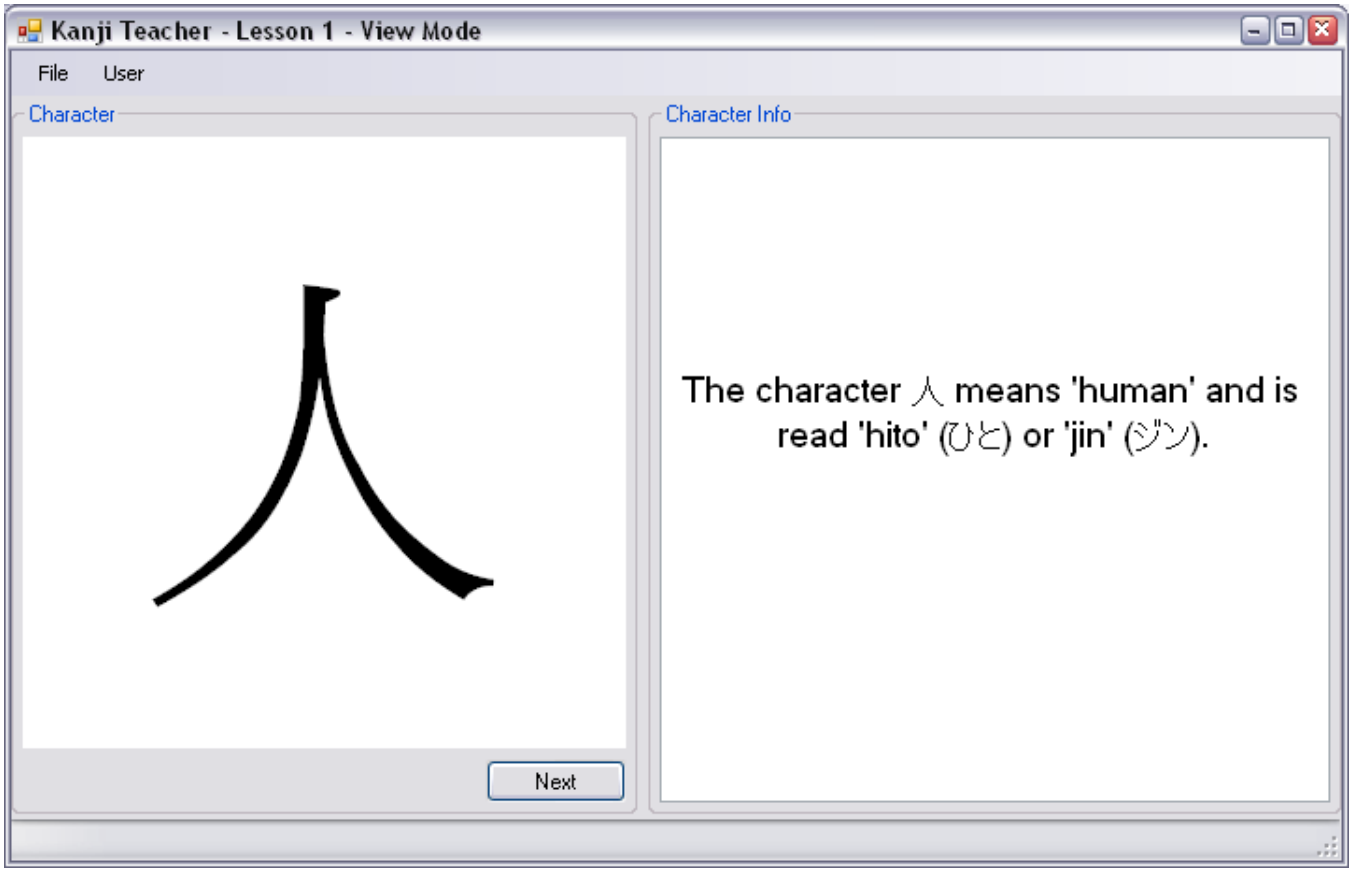

Figure 1.7: Character view mode

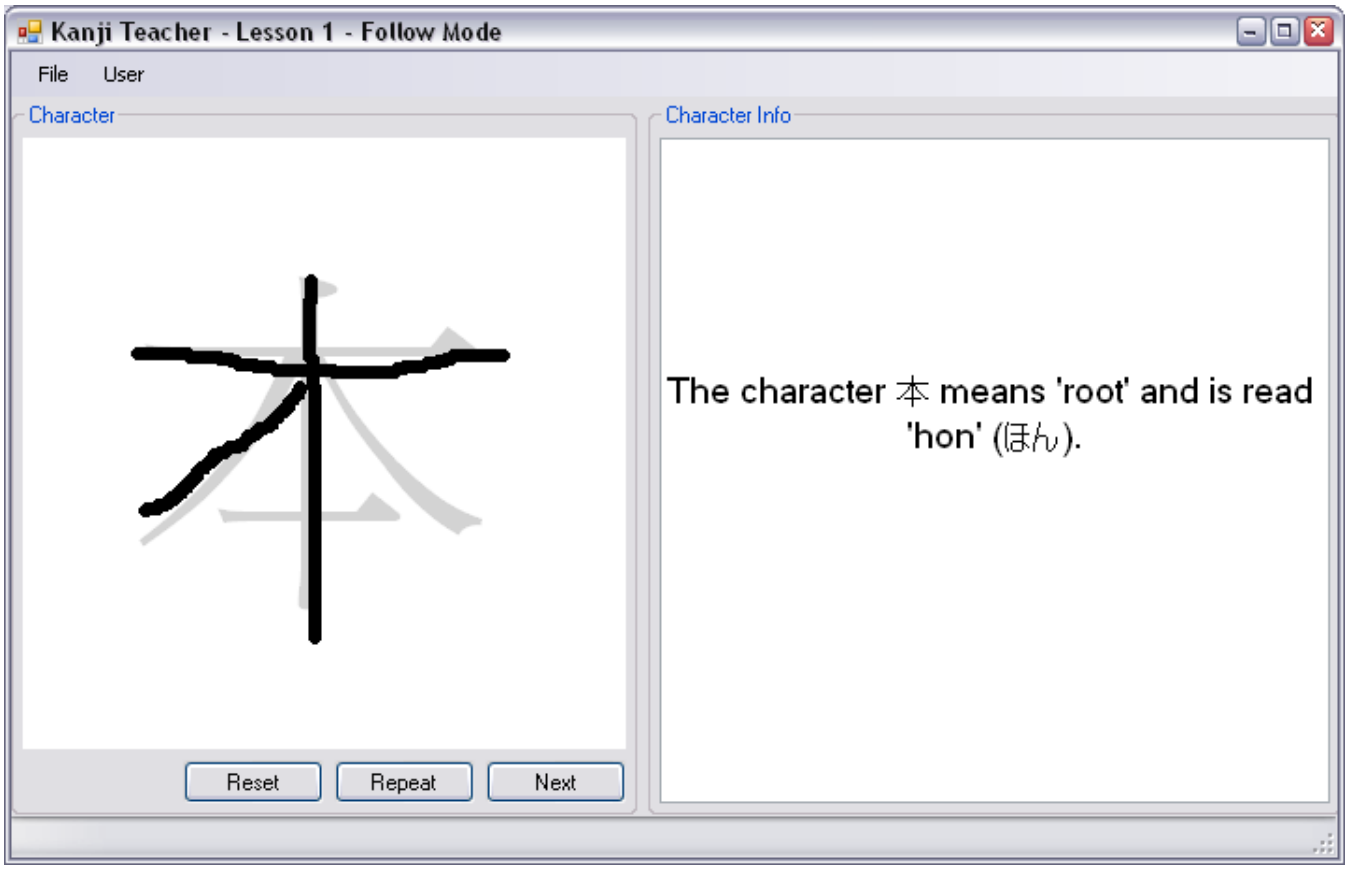

Figure 1.8: Follow mode for drawing new characters

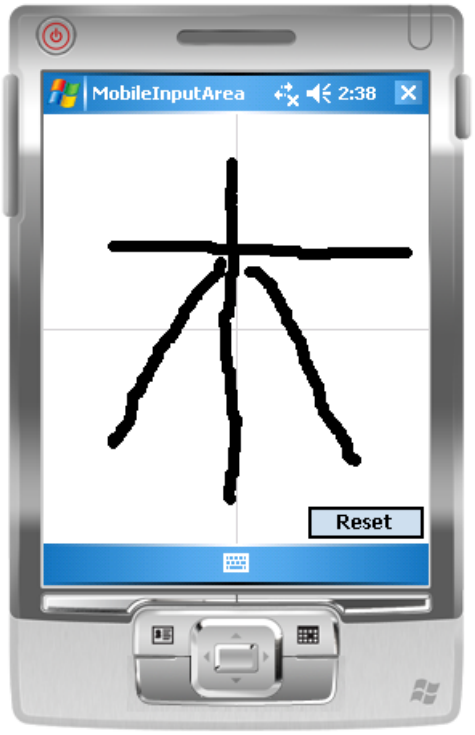

Figure 1.9: Mobile device character input

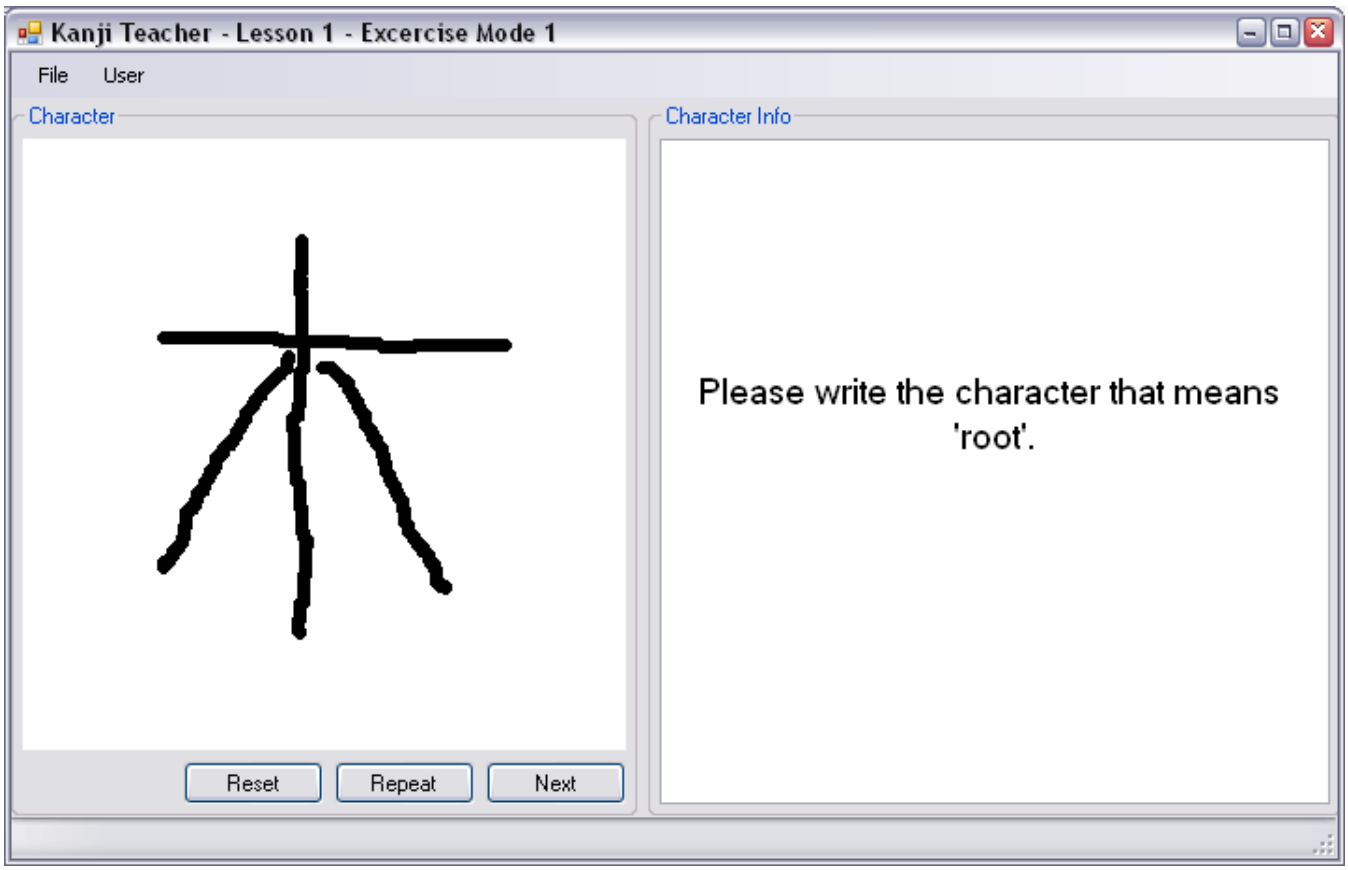

Figure 1.10: Exercise mode 1 for input of Kanji from English source

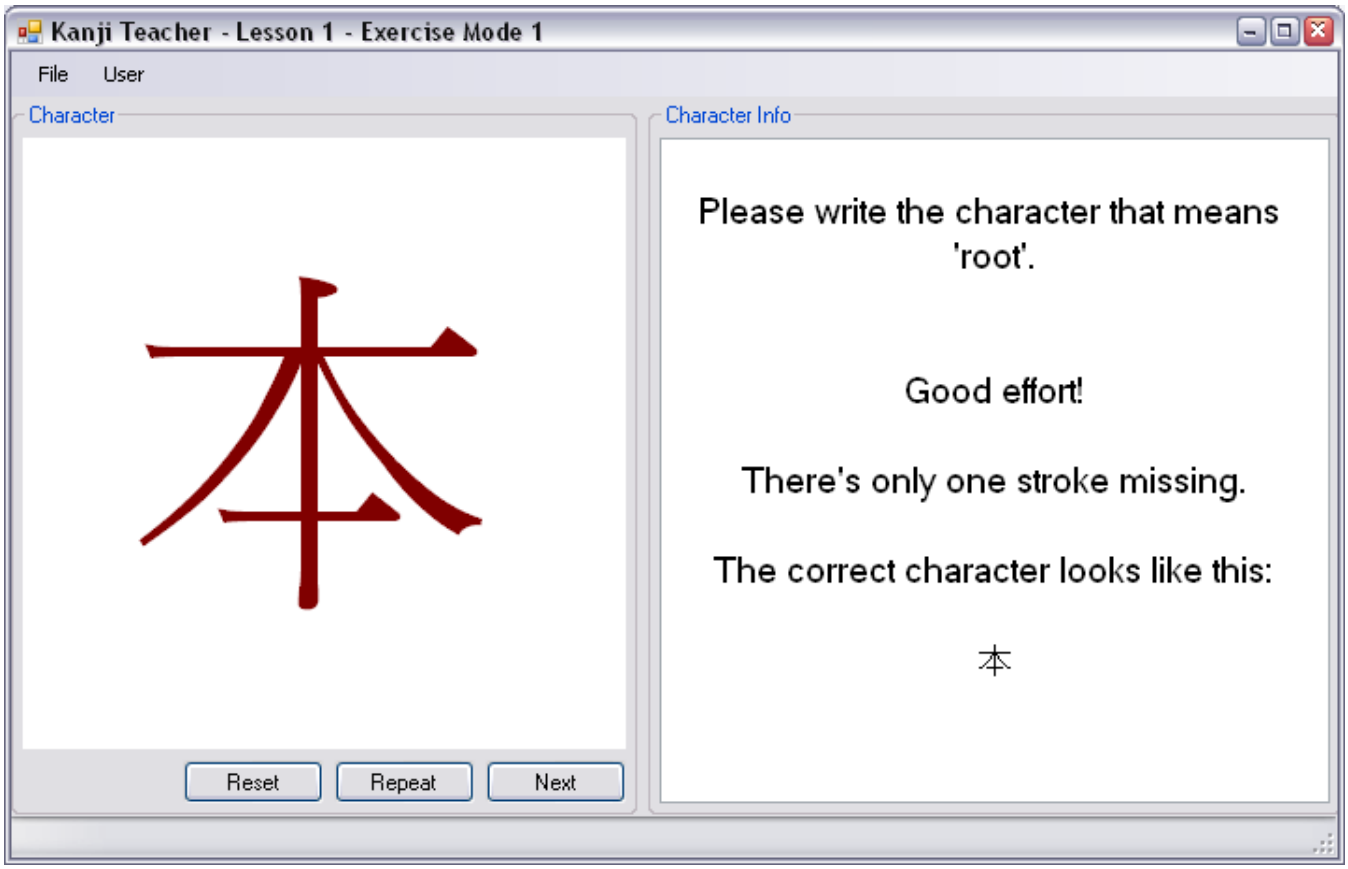

Figure 1.11: Exercise mode 1 after user entered almost correct character

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Alexander, S. and T. Golja (2007). Using Students' Experiences to Derive Quality in an E-Learning System: An Institution's Perspective. *Educational Technology and Society 10*(2), 17--33.

Chua, B. B. and L. E. Dyson (2004, Dec). Applying the ISO 9126 Model to the Evaluation of an E-Learning System. In *Proc. of ASCILITE 2004*, Perth, Australia, pp. 184--190.

Foljanty, D. (1984). Die japanische Schrift (in german). In Institut für deutsche Sprache Mannheim, T. Kaneko, and G. Stickel (Eds.), *Japanische Schrift, Lautstrukturen, Wortbildung*, Volume 1 of *Deutsch und Japanisch im Kontrast*, Chapter 2, pp. 29--63. Heidelberg: Julius Groos Verlag.

Hadamitzky, W. (1995). *Kanji und Kana*, Volume 1 of *Kanji und Kana*. Berlin: Langenscheidt KG.

Hamid, A. A. (2001). e-Learning: Is it the "e" or the Learning That Matters? *The Internet and Higher Education 4*(3-4), 311--316.

Hettinger, J. (2008). *E-Learning in der Schule (in German)*. Munich, Germany: kopaed Verlag.

Ismail, J. (2002). The Design of an E-Learning System: Beyond the Hype. *The Internet and Higher Education 4*(3-4), 329--336.

Ivašin, M. (2009). Lernen und Technologie (in German). In B. Mikuszeit and U. Szudra (Eds.), *Multimedia und ethische Bildung*, Chapter 5.5, pp. 635--648. Frankfurt am Main, Germany: Peter Lang.

Kahiigi, E. K., L. Ekenberg, H. Hansson, F. Tusubira, and M. Danielson (2008). Exploring the E-Learning State of Art. *The Electronic Journal of E-Learning 6*(2), 77--88.

Richert, A. S. (2007, Dec). *Einfluss von Lernbiografien und subjektiven Theorien auf selbst gesteuertes Einzellernen mittels E-Learning am Beispiel Fremdsprachenlernen (in German)*. Ph. D. thesis, RWTH Aachen, Aachen. Manuscript committee: Prof. Dr. phil. Rudolf Beier, Prof. Dr. phil. Uwe Michelsen.

Stahlmann, R. (2004). Didaktische, inhaltliche und funktionelle Optimierung einer selbst entwickelten Chinesischlernsoftware (in German). Master's thesis, Offenburg University of Applied Sciences, Offenburg, Germany. Manuscript committee: Prof. Dr. Roland Riempp (supervisor), Prof. Dr. Thomas Breyer-Mayländer.

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