# JollyMate: Assistive Technology for Young Children with Dyslexia

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## Abstract

*In this paper, we describe Jollymate, a product concept that we have envisioned as assistive technology for young children with Dyslexia. Jollymate, a digital notepad, emulates the Jolly Phonics system of teaching letter sounds and letter formation to children with dyslexia. Jollymate in turn uses simple handwritten character recognizers created using the Lipi IDE tool from the Lipi Toolkit project, for detecting when a character has been written incorrectly. In this paper we describe the Jollymate concept in brief, the Lipi IDE tool used to create the recognizers, and their integration.*

## 1. Introduction

Dyslexia is a language-based learning disability that refers to a cluster of symptoms, which result in people having difficulties with specific language skills, particularly reading [1]. Students with dyslexia usually experience difficulties with other language skills such as spelling, writing, and pronouncing words. Accompanying weaknesses such as difficulty with sequencing, trouble with directional words, audio and visual perception, short-term memory, motor skills, amongst many other indicators, manifest themselves at an early stage. Dyslexia is frequently accompanied by *dysgraphia*, which refers to an impaired ability to acquire written language and use written language to express thoughts. Dysgraphia generally manifests as impaired letter writing by hand, and sometimes spelling as well.

Conventional methods of teaching are often not effective for dyslexic children. However, the effects of dyslexia and dysgraphia can be countered with appropriate pedagogic techniques and the use of information technology.

## 2. Jollymate

Jollymate is a self-learning device for dyslexic children. Designed in the form of a school notebook, it enables the child to practice how to write letters and numbers correctly using Jolly Phonics [3], a system specifically designed to teach letter sounds and letter formation of the English language to children with this learning difference. The Phonics program consists of six 'letter sound' groups that have been carefully classified to assist learning. For example, one of these sets is {s, a, t, i, p, n}. The letters are introduced not just visually, but also through their sounds, and an action. For example, the letter 's' can be introduced through a story featuring a snake, where the 'ssss…' sound of the snake is emphasized, and the wavy action of the snake is also performed. The child can then relate the visual form of the letter to its sound, and its action, and remember it better,

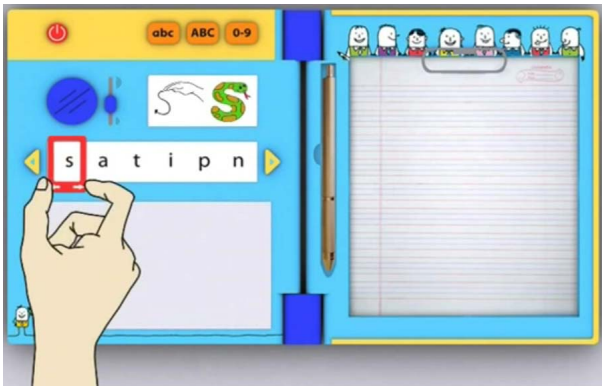


**Figure 1. Jollymate: Selection of specific letter using the slider**

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Jollymate emulates this learning methodology in its design. On turning the notebook on (Figure 1), the child can select the mode (letters or numerals) and the case (lower/upper). A 'letter sound' set of choice can be selected using the arrow buttons and a specific letter sound can be selected using the slider.

Upon selection, audio visual feedback corresponding to that letter sound is activated and the child is ready to practice in the work area on the right. If the letter is written correctly, a star is displayed to indicate success at letter formation. However, if the letter is wrongly formed, for example, mirrored, Jollymate recognizes the mistake and provides auditory feedback instructing the child to continue practicing. To facilitate this, in the practice area on the lower left, an animated path of the character is displayed, along with characters to assist training. The child can follow the path of this character by tracing over the guides. Each success is indicated by a star. On completing the exercise, the child can move onto practicing another character in the work area. The user can switch to any character of choice during a session.

## 3. Lipi Toolkit

Lipi Toolkit [2,3] from HP Labs is an open source project whose aim is to facilitate development of online handwriting recognition engines for new scripts, and simplify integration of the resulting engines into real-world applications. The toolkit provides robust implementations of tools, algorithms, scripts and sample code necessary to support activities ranging from handwriting data collection and annotation, training and evaluation of recognizers, packaging of engines, and their integration into pen-based applications. The toolkit aims to satisfy the requirements of a diverse set of users, such as HWR researchers, do-it-yourself enthusiasts and application developers.

The first version released in Oct 2006 contained basic algorithms for isolated character or shape recognition: Subspace-based classification (PCA), and Nearest-Neighbor classification based on Dynamic Time Warping (DTW). Both recognizers used fixed-length representations of the handwritten shape trajectory, obtained after preprocessing operations such as size normalization and resampling.

The toolkit is now in its third version, and includes many new preprocessing functions and new features such as *PointFloat* [7]. It also includes several additional shape recognizers, including (i) a generalized k-Nearest Neighbor classifier which supports both Euclidean and DTW distance, (ii) a classifier based on Active-DTW [5], and (iii) a Neural Network-based classifier.

The toolkit has also seen significant additions to make it more useful to application developers without any background in handwriting recognition. For example, the project now also provides "pre-built" recognizers for standard character sets such as Latin numerals, lowercase and uppercase letters, and various Indic character sets, which can be integrated into applications without the need for data collection or training. Another significant addition has been an "Integrated Development Environment" or IDE which allows even lay users without development skills to create new recognizers for arbitrary sets of handwritten shapes. This tool is described in more detail in the following section.

## 4. Lipi IDE

Lipi IDE is a Java tool to simplify the creation of creation and packaging of new Lipi recognizers via a graphical user interface. It can be used for the rapid creation of recognizers for a set of handwritten shapes (characters, gestures etc) by a non-specialist.

### 4.1. User Interface

The IDE user interface shown in Figure 2 is implemented in Java and provides the user with the ability to create a new recognizer (called a Lipi "project"), specify pattern classes by directly entering training samples, test the recognizer using new samples, and package the recognizer for subsequent integration into an application – all from a single user interface. The tool may be used to rapidly create recognizers for arbitrary sets of multistroke symbols.

### 4.2. Architecture

The architecture of the IDE tool is shown in Figure 3. The IDE uses JNI to communicate user input to a shape recognizer – specifically a nearest neighbor classifier that uses DTW distance. The training samples provided by the user are after suitable preprocessing used directly as prototypes by the recognizer. The choice of a prototype-based classifier is natural given that there may only be a small number of training samples available, and training samples, and even entire pattern classes (e.g. a new gesture) may be added or deleted dynamically by the user. The complexity of invoking API calls for training and testing the recognizer, or creating and deleting samples and pattern classes, is hidden from the user, who only deals with the graphical interface. Further details of the use of the IDE, and of the preprocessing, feature extraction and matching may be found in the Lipi IDE

User Manual [6] and the Lipi Core Toolkit Reference Manual [7] respectively.

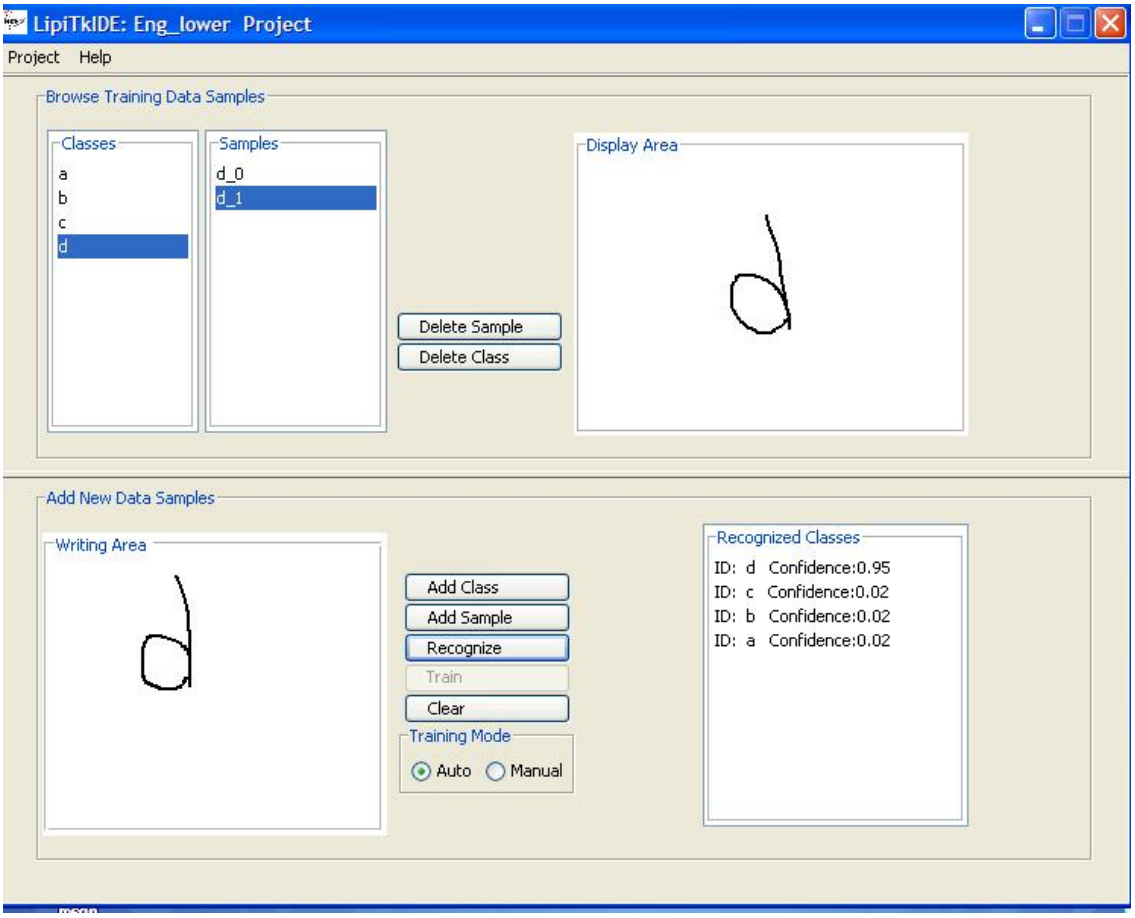


**Figure 2. Lipi IDE User Interface**

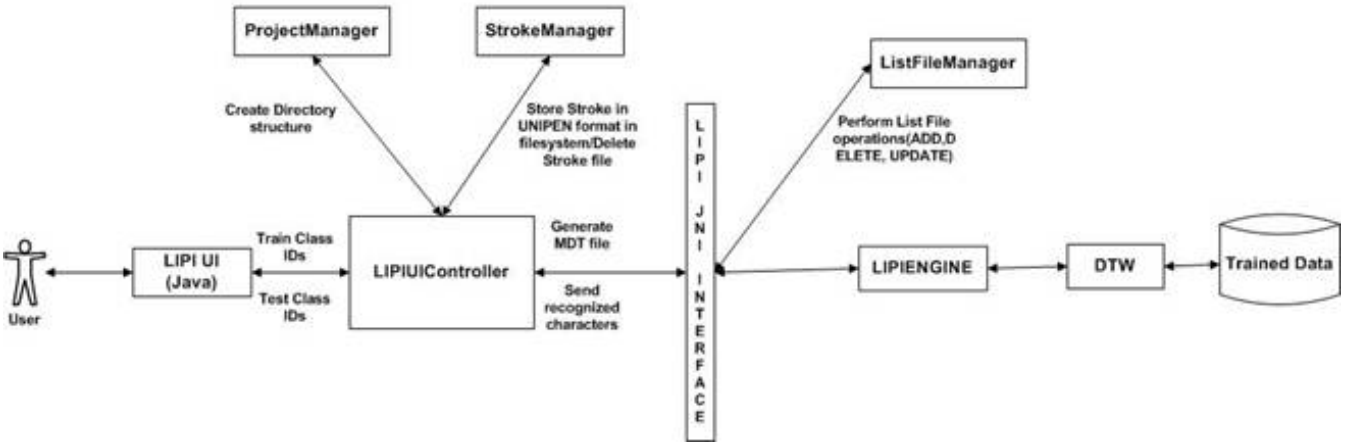


**Figure 3. Lipi IDE Architecture**

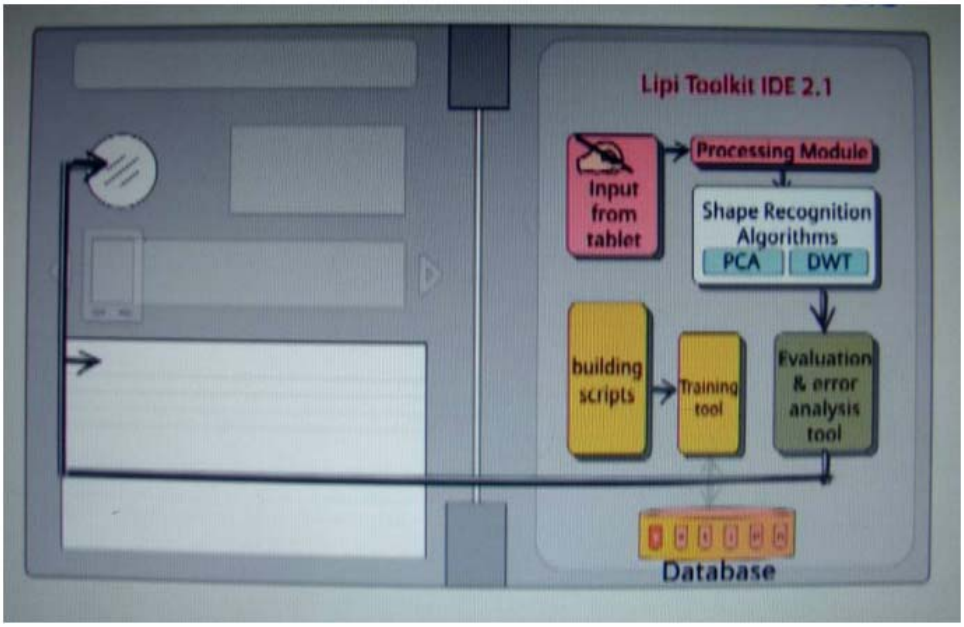


**Figure 4. Schematic representation of control flow**

## 5. Application to Jollymate

As already described, Jollymate is designed to assist children with the writing of upper and lowercase letters, numerals as well as phonics. Specific shape recognizers for these character sets were first created using the Lipi IDE tool. The flow of control at run-time (depicted visually in Figure 4) may be described as follows:

- The Lipi engine loads the appropriate shape recognizer according to the mode (uppercase, lowercase, numerals, phonics) selected. Since the child also selects the specific letter, the ground truth of the letter being written is known in advance.

- When the child writes on the notepad, the input is sent to the Lipi engine and is preprocessed by the Generic Preprocessing Module [7], which takes care of size and other variations.

- The Nearest Neighbor classifier [7] is used to match the input with the training samples of the specific letter class. A threshold on the normalized DTW distance is used to determine whether the letter was correctly written.

- If the letter is correct, visual feedback is provided by calling the slider screen's flash function, and the letter gets converted into a star and the audio feedback of the applause sound is played.

- If the letter is wrong, this is communicated to the user using the touch screen's flash function and an audio instruction. The application then disables the sensing of the tablet.

## 6. Conclusions

In this paper, we have described Jollymate, a product concept aimed at assisting dyslexic children with letter formation. The concept uses isolated handwritten character recognizers built using the Lipi IDE tool from Lipi Toolkit. For the proof of concept, the integration of the recognizer for a subset of the supported classes has been tested.

Future work will include supporting the entire set of characters including the phonics, and more rigorous and extended testing with end users to understand recognition performance and issues of usability and user acceptance.

While not implemented in the current proof of concept, the use of the IDE makes it possible in theory

to train the recognizer using correctly written samples of the child's own writing, as opposed to some idealized style. This is significant given the stroke order and stroke direction variations that may be expected across writers.

Given that dyslexic users also often face issues with spelling and word formation, the concept can be extended to include the writing of entire words, using available word recognition techniques from Lipi Toolkit.

## Acknowledgements

Jollymate was conceived, designed and prototyped during a classroom project on Embedded Systems and Interaction Design by the New Media Design postgraduate students – Sagar Raut, Neety Rai, Ritika Mathur and Shailja Pahuja – at the National Institute of Design. Author 1 was the primary guide for this academic project.

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