



# Intel Recognition Primitives Library

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## What's New in Version 3.0

The Recognition Primitives Library Version 3.0 includes, for the first time, a DLL and static library optimized for the Pentium® Processor with MMX™ technology. The new assembly language optimized code takes advantage of MMX technology to accelerate the integer functions in the library. Additional Pentium Processor and Intel 486™ optimizations have also been added, as well as error checking functionality similar to that of the Intel Signal Processing Library. Also added is the ability for the user to make custom DLL and LIB files that contain only the image recognition library functions that the user's application actually calls.

## What is the Intel Recognition Primitives Library?

The Intel Recognition Primitives (RP) Library provides developers of speech- and character-recognition software a set of recognition primitives optimized for speed on the Intel Architecture. The recognition primitive functions address the most compute-intensive parts of typical speech- and character-recognition applications.

The use of Rich Media in the form of speech, video and images is becoming more and more prevalent on the desktop computer. With this trend, there is not only a need to present and manipulate Rich Media, but also a need to interpret content. Recognizing important information within Rich Media enables applications to do verbal command and control, speech transcription, and searching and indexing of documents and voice mail. Speech and character recognition are key ingredients in this growing technology.

The process of extracting computer-usable information from Rich Media consists of two basic steps: feature extraction and classification.

**Feature extraction** is a process of reducing natural data by measuring certain characteristics (features) of an instance of natural data just enough to be able to distinguish that instance from other relevant classes of that natural data. For example, stroke parameters are extracted from a set of X,Y coordinates entered via a pen on a digitizing tablet for the purpose of classifying the strokes into one of 36 character classes. Feature extraction is very specific to the natural data type being processed and the type of discrimination to be made. Feature extraction is closely related to data compression: in both cases the goal is to reduce natural data to a more essential form.

The Intel Recognition Primitives library provides some feature extraction functions specific to speech and others specific to document images. The library functions for classification, however, generally apply to both speech and character recognition.

**Classification** is the process of comparing an instance of features to many reference feature sets and deciding to which class that instance of features is most similar according to some metric such as Dot Product, Euclidean, or Mahalanobis.

More complex classifiers use functions of the similarity measures to estimate probabilities. Such classifiers include information about the characteristic variability of the data being recognized. The Gaussian mixture and MLP Neural Network functions are included in the Recognition Primitives Library for these more complex classifiers. When classes are mutually exclusive and exhaustive, Gaussian mixture models can provide a confidence or probability estimate of its class decision. MLP does not provide confidence measures.

Hidden Markov Models (HMM) and Dynamic Time Warping (DTW) are elastic matching techniques used when the natural data has a dimension in which the data is distorted. This dimension includes: time for continuous speech and the left-to-right direction for cursive handwriting. DTW functions are included in this revision of the library along with a demonstration. Program Hidden Markov Models and the Viterbi algorithm are also included in this revision of the library.

## Recognition Primitives Library Content

- **Vector Operations:** Initialization, Arithmetic, Logical
- **Signal Processing:** Windowing, FFT
- **Speech Signal Processing:** Signal Pre-emphasis, Cepstral Analysis
- **Recognition Basics:** Dot Products, Mahalanobis and Euclidean Distances, Gaussian Mixtures, MLP Neural Network, Vector Quantization/Kohonen Network, Dynamic Time Warping.
- **Image Processing:** Pixel Arithmetic and Logical Operations, Image Geometric Transformations, Mask Convolution

## Representative Performance Specifications

Function Name	Pentium Floating Point Performance	Pentium w MMX Integer Performance
64 dim. Dot product	3.973 clocks per MAC	1.436 clocks per MAC
49 dim. Euclidean Distance Squared	106 $\mu$ sec.	34.2 $\mu$ sec.
512 pt. Windowing	32.7 $\mu$ sec.	9.81 $\mu$ sec.
512pt. Real FFT	175 $\mu$ sec.	122 $\mu$ sec.
10 Cepstral Coefficients, 512 pt. input	923 $\mu$ sec.	654 $\mu$ sec.
20 Dim. x 4 Gaussian Mixtures	457K Gaussians/sec.	827K Gaussians/sec.
155x184x165x16 MLP Neural Network	14.2M Connections/sec.	43.3M Connections/sec.

(The performance specifications above are results averaged over many repetitions of each function call. Data is in cache. Results were measured using a 150MHz Pentium® processor PC with a 256K second level cache and a 150 MHz Pentium® with MMX processor PC with a 256K second level cache. The tests were run under Windows\* 95)

Version 1.0 was the first public release of the RP Library. It was originally released to alpha sites in mid-March of 1995 and given general distribution on the IAL June 1995 CD ROM. It consisted of a Pentium-optimized static library form of the functions. Version 2.0 released in September 1995 added processor-specific, dynamically linked libraries (DLLs).

A DLL detects the processor type at the time the DLL is loaded and loads a processor-specific DLL which is optimized for either the Intel486(TM), Pentium processor, Pentium processor with MMX™ technology or the Pentium Pro Processor.

This release, Version 3.0 distributed on the Performance Tool Set (PTS) CD-ROM, uses MMX technology to accelerate the integer functions within the library. Both a static library and a processor specific DLL are provided which take advantage of MMX technology.

The Library includes an application (Windows\* NT, Windows\* 95, Win32s\* compatible) which will measure the performance of the library functions on any Intel Architecture based PC. Source code for the test program and a MAK file are provided should you wish to modify the way the performance is tested to be more relevant to your application. A demonstration program that uses the image processing functions in the library is also included along with the source code and a MAK file.

## Technical Information

- A data sheet for the Intel Recognition Primitives Library reports performance ratings for various speech and optical character recognition functions.
- The *Intel Recognition Primitives Library Reference Manual*, order number 637785, describes the functions in the Recognition Primitives Library. Each function is introduced by its name and a short description of its purpose. This is followed by a function prototype and definitions of its arguments. Finally there is a discussion of the algorithm and its implementation.

## Installing the Recognition Primitives Library

To use the Recognition Primitives Library, you must install it.

### License Considerations

This software is licensed under the terms and conditions set out in the `license.wri` file in the root directory of the CD-ROM. Please read the license carefully before using the software. The release notes for this release of the Recognition Primitives Library are installed during the library installation.



# Image Processing Demo

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## Image Processing Demo Instructions

The demo program `rlimage.exe` uses the image processing functions in the Recognition Primitives Library and is provided in the directory `\bin`. This demo can be run on Windows\* NT, Windows\* 3.1 and Windows\* 95.

**NOTE:** Win32s\* is required to run this program. If you try to run it without the Win32s software installed, you will get a blank screen and then be returned to the screen from which the demo was launched. The Win32s software can be installed from this CD. To install from Program Manager, select **File, Run** and type in:

```
{CD-ROM drive letter}:\install\win32s\disk1\setup
```

A make file, `rlimage.mak`, source files and other support files are provided in the directory `\examples\img_demo` should you wish to rebuild the program using Microsoft Visual C++\* v2.2. Sample images in the form of bitmap files are provided in the demo directory. (If you have installed the libraries, bitmap files may also be found in `\examples\img_demo\samples`.)

To run the program, execute `rlimage.exe`. Then select an image file by using the **Open** option in the **File** menu or by clicking on the **File Open** icon. The input image will now be visible. You can choose one of the `.BMP` images in the provided same directory. Select one of the functions: **Rotate**, **Convolve**, **Mirror**, or **Invert** from the **ImageProcessing** menu. The processed output image will display alongside the original image.



# Handwritten Character Recognition Demo

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## Handwritten Character Recognition Demo Instructions

A demo program, DTW\_DEMO, using the Dynamic Time Warping functions in the library, is provided in the directory `\bin`. A complete on-line help file is included with the demo. DTW\_DEMO can be run on Windows NT, Win 3.1 (it requires Win32s) and Windows 95. A make file `dtw_demo.mak`, source files, and other support files are provided in the directory `\examples\dtw_demo` should you need to rebuild the program using Microsoft Visual C++ v. 2.2. Sample handwritten character templates are provided with the extension `.hws`.

To run the demo, execute `dtw_demo.exe`. The demo will let you perform these tasks:

- Draw a character in a file, then let DTW\_DEMO recognize the character.
- Select different DTW algorithms and vary the input parameters. See how they influence the results.
- Increase DTW\_DEMO's chances of recognizing a character correctly by creating your own templates of handwritten characters which will be used in addition to the templates provided by the demo.
- Use the DTW\_DEMO application to recognize a character in one of the `.hws` character template files.

The on-line help describes all of these tasks and more. The on-line help is accessible through the **Help** menu on the DTW\_DEMO GUI.

## Technical Support and Feedback

To give feedback or to report any problems with installation or use, use the contact information in the customer letter included with your CD-ROM package.