The Speech Recognition Manager Revealed

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As any Star Trek fan knows, the computer of the future will talk and listen. Macintosh computers have already been talking for a decade, using speech synthesis technologies such as Macintalk or the Speech Synthesis Manager. Now any Power Macintosh application can use Apple’s new Speech Recognition Manager to recognize and respond to spoken commands as well. In this article, we’ll show you how easy it is to add speech recognition to your application.

Speech recognition technology has improved significantly in the last few years. It may still be a long while before you’ll be able to carry on arbitrary conversations with your computer. But if you understand the capabilities and limitations of the new Speech Recognition Manager, you’ll find it easy to create speech recognition applications that are fast, accurate, and robust.

With code samples from a simple speech recognition application, SRSample, this article shows you how to get started using the Speech Recognition Manager quickly. You’ll also get some tips on how to make your application’s use of speech recognition compelling, intuitive, and reliable. For all the technical details, check out the *Inside Macintosh* chapter “Speech Recognition Manager,” included on the accompanying CD along with SRSample.

WHAT THE SPEECH RECOGNITION MANAGER CAN AND CANNOT DO

The Speech Recognition Manager consists of an API and a recognition engine. Under System 7.5, these are packaged together in version 1.5 or later of the Speech Recognition extension. (This packaging may change in future OS versions.)

The Speech Recognition Manager runs only on Power Macintosh computers with 16-bit sound input. Speech recognition is simply too computation-intensive to run well on most 680x0 systems. The installed base of Power Macs is growing by about five million a year, however, so plenty of machines — including the latest PowerPC processor–based PowerBooks — can run speech recognition.

The current recognition has the following capabilities and limitations:

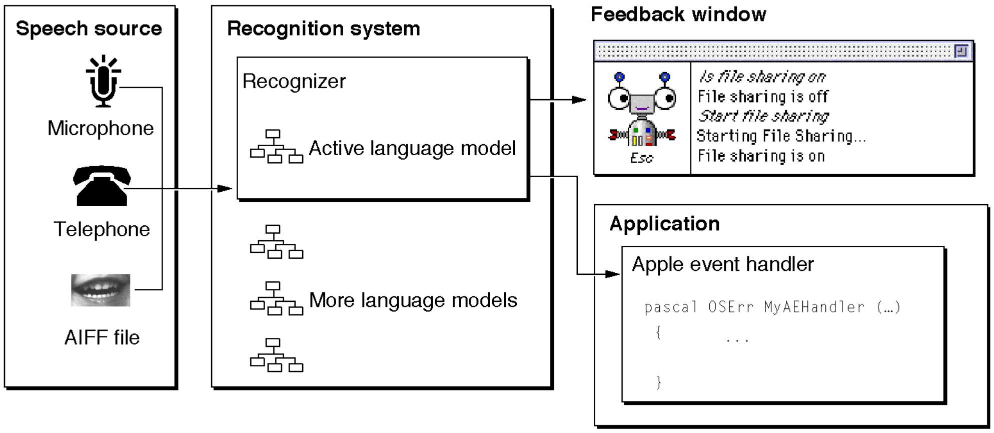
- It’s speaker independent, meaning that users don’t need to train it before they can use it.
- It recognizes continuous speech, so users can speak *naturally*, without — pausing — between — each — word.
- It’s designed for North American adult speakers of English. It’s not localized yet, and in general it won’t work as well for children.
- It supports command-and-control recognition, not dictation. It works well when your application asks it to listen for at most a few dozen phrases at a time, but it can’t recognize arbitrary sentences and its accuracy decreases substantially if the numbe of utterances it’s asked to listen for grows too large. For example, it won’t accurately recognize one name out of a list o five thousand names.

OVERVIEW OF THE SPEECH RECOGNITION MANAGER API

To use the Speech Recognition Manager, you must first open a *recognition system*, which loads and initializes the recognition toolbox and specifies which speech recognition services are available. (Currently, only short English utterances can be recognized.) You then allocate a *recognizer,* which listens to a *speech source* for sound input. A recognizer might also display a *feedback window* that shows the user when to speak and what the recognizer thinks was said.

To define the spoken utterances that the recognizer should listen for, you build a *language model* and pass it to the recognizer. A language model is a flexible network of words and phrases that defines a large number of possible utterances in a compact and efficient way. The Speech Recognition Manager lets your application rapidly change the *active* language model, so that at different times your application can listen for different things.

After the recognizer is told to start listening, it sends your application a *recognition result* whenever it hears the user speak an utterance contained in the current language model. A recognition result contains the part of the language model that was recognized and is typically sent to your application via Apple events. (Alternatively, you can request notification using callbacks if you cannot support Apple events.) Your application then processes the recognition result to examine what the user said and responds appropriately. This speech recognition scheme is shown in Figure 1.



Is file sharing on
File sharing is off
Start file sharing
Starting File Sharing...
File sharing is on

```
pascal OSErr MyAEHandler (…)
 {        ...


 }
```

Figure 1.
The speech recognition scheme. Telephone input is not supported in Version 1.5 of the Speech Recognition Manager.

SPEECH OBJECTS

The recognition system, recognizer, speech source, language models, and recognition results are all objects belonging to classes derived from the SRSpeechObject class, in accordance with object-oriented design principles. These and other objects are arranged into the class hierarchy shown in Figure 2. The class hierarchy gives the Speech Recognition Manager API the flexibility of polymorphism. For example, you can call the routine SRReleaseObject to dispose of any SRSpeechObject.

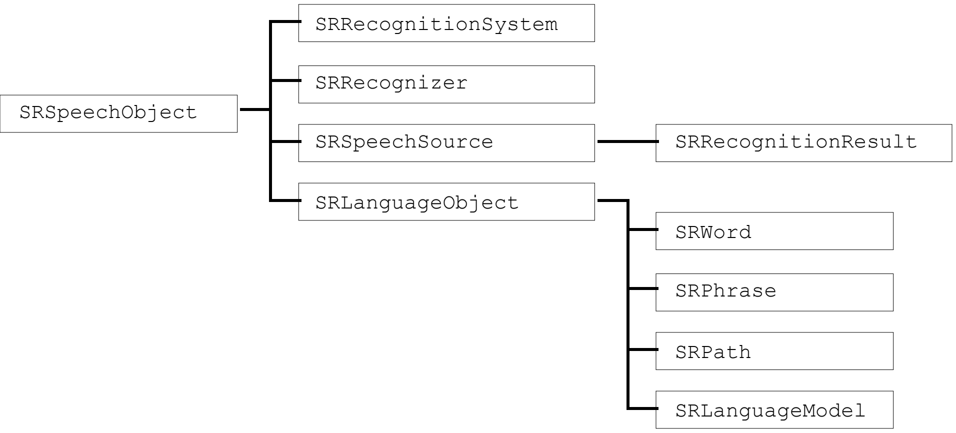


Figure 2.
The speech object class hierarchy

The most important speech objects are as follows:

- SRRecognitionSystem — An application typically opens one of these at startup (by calling SROpenRecognitionSystem) and closes it at shutdown (by calling SRCloseRecognitionSystem). Applications allocate other kinds of objects by calling routines like SRNewWord, which typically take the SRRecognitionSystem object as their first argument.

- SRRecognizer — An application gets an SRRecognizer from an SRRecognitionSystem by calling SRNewRecognizer. The SRRecognizer does the work of recognizing utterances and sending recognition results back to the application. It begins doing this whenever the application calls SRStartListening and stops whenever the application calls SRStopListening.

- SRLanguageModel, SRPath, SRPhrase, SRWord — An application builds its language models from these object types, which are all subclasses of SRLanguageObject. (A *phrase* is a sequence of one or more words, and a *path* is a sequence of words, phrases, and language models.) A language model, in turn, describes what a user can say at any given moment. For example, if an application displayed ten animals and wanted to allow the user to say any of the animals' names, it might build a language model containing ten phrases, each corresponding to an animal's name.

- SRRecognitionResult — When an utterance is recognized, an SRRecognitionResult object is sent (using either an Apple event or a callback routine, whichever the application prefers) to the application that was listening for that utterance. The SRRecognitionResult object describes what was recognized. An application can then look at the result in several forms: as text, as SRWords and SRPhrases, or as an SRLanguageModel, which can assist in automatic parsing of the uttered phrase.

Each class of speech object has a number of properties that define how the objects behave. For example, all descendants of SRLanguageObject have a kSRSpelling property that shows how they're spelled. Your application uses the SRSetProperty and SRGetProperty routines to set and get the various properties of each these objects.

RELEASING OBJECT REFERENCES

You create objects by calling routines like SRNewRecognizer and SRNewWord. When you've finished using them, you dispose of them by calling SRReleaseObject. You can also acquire references to existing objects by calling routines like SRGetIndexedItem (for example, to get the second word in a phrase of several words).

The Speech Recognition Manager maintains a reference count for each object. An object's reference count is incremented by calls to SRNewXXX and SRGetXXX, and is decremented by calls to SRReleaseObject. An object gets disposed of only when its reference count is decremented to 0. Therefore, to avoid memory leaks, your application *must* balance every SRNewXXX or SRGetXXX call with a call to SRReleaseObject.

A SIMPLE SPEECH RECOGNITION EXAMPLE

It's easy to add simple speech recognition capabilities to your application. All you need to do is perform a small number of operations in sequence:

1. Initialize speech recognition by determining whether a valid version of the Speech Recognition Manager is installed, openin an SRRecognitionSystem, allocating an SRRecognizer, and insstalling an Apple event handler to handle recognition result notifications.

2. Build a language model that specifies the utterances your application is listening for.

3. Set the recognizer's active language model to the one you built and call SRStartListening to start listening and processing recognition result notifications.

We'll describe each of these operations in more detail.

INITIALIZING SPEECH RECOGNITION

First, you must verify that a valid version of the Speech Recognition Manager is installed on the target machine. Listing 1 shows how to do this. Note that only versions 1.5 and later of the Speech Recognition Manager adhere to the API used in this article.

Listing 1.

Determining the Speech Recognition Manager version

```
Boolean HasValidSpeechRecognitionVersion (void)
{
       OSErr                                   status;
       long                                    theVersion;
       Boolean                                 validVersion                   = false;
       const unsigned long   kMinimumRequiredSRMVersion   = 0x00000150;

       status = Gestalt (gestaltSpeechRecognitionVersion, &theVersion);
       if (!status)
              if (theVersion >= kMinimumRequiredSRMVersion)
                     validVersion = true;

       return validVersion;
}
```

Listing 2 shows how to open an SRRecognitionSystem, allocate an SRRecognizer, and install your Apple event handler. All of this happens when your application starts up. The Apple event handler HandleRecognitionDoneAE is described later (Listing 4).

Listing 2.

Initializing the Speech Recognition Manager

```
/* Our global variables */
SRRecognitionSystem  gRecognitionSystem   = NULL;
SRRecognizer                gRecognizer                       = NULL;
SRLanguageModel             gTopLanguageModel           = NULL;
AEEventHandlerUPP    gAERoutineDescriptor  = NULL;

OSErr InitSpeechRecognition (void)
{
       OSErr status = kBadSRMVersion;

       /* Ensure that the Speech Recognition Manager is available. */
       if (HasValidSpeechRecognitionVersion ())  {
              /* Open the default recognition system. */
              status = SROpenRecognitionSystem (&gRecognitionSystem, kSRDefaultRecognitionSystemID);

              /* Use standard feedback window and listening modes. */
              if (!status) {
```

```
                        short feedbackNeeded = kSRHasFeedbackHasListenModes;

                        status = SRSetProperty (gRecognitionSystem, kSRFeedbackAndListeningModes,
                                                                                 &feedbackNeeded,
sizeof(feedbackNeeded));
                }

                /* Create a new recognizer. */
                if (!status)
                        status = SRNewRecognizer (gRecognitionSystem, &gRecognizer, kSRDefaultSpeechSource);

                /* Install our Apple event handler for recognition results. */
                if (!status) {
                        status = memFullErr;
                        gAERoutineDescriptor = NewAEEventHandlerProc (HandleRecognitionDoneAE);

                        if (gAERoutineDescriptor)
                                status = AEInstallEventHandler (kAESpeechSuite, kAESpeechDone, gAERoutineDescriptor,
                                                                                                              0,
false);
                }
        }

        return status;
}
```

Notice how we call SRSetProperty to request Apple's standard feedback and listening modes for the recognizer. To have a successful experience with speech recognition, users need good feedback indicating when the recognizer is ready for them to talk and what utterances the recognizer has recognized (see "Speech Recognition Tips"). In addition, because of the recognizer's tendency to misinterpret background conversation and noises as speech, it's usually a good idea to let the user tell the recognizer when to listen by pressing a pre-defined key (the "push-to-talk" key). Your application can get all of this important behavior for free, simply by setting the kSRFeedbackAndListeningModes property as shown in Listing 2. Users can use Apple's Speech control panel (which comes bundled on new Macintoshes and on system updates) to tailor the behavior to suit their needs, choosing preferred feedback characters (that is, the faces displayed in the feedback window) and preferred push-to-talk keys.

BUILDING A SIMPLE LANGUAGE MODEL

Your application needs to build a language model — gTopLanguageModel in our sample code — that specifies what the recognizer is listening for. Listing 3 shows how your application can create a simple language model. (We'll discuss fancier language models later in this article.) Even simple language models should avoid using phrases that sound similar to one another; just like a human listener, the recognizer may have a hard time distinguishing between similar-sounding phrases.

Listing 3.

Building a simple language model

```
OSErr BuildLanguageModel (void)
{
       OSErr                       status        = noErr;
       const char            kLMName[]     = "<TopLM>";

       /* First, allocate the gTopLanguageModel language model. */

       status = SRNewLanguageModel (gRecognitionSystem, &gTopLanguageModel, kLMName,
                                                                                strlen (kLMName));

       if (!status) {
              long refcon = kTopLMRefcon;

              /* Set the refcon of our top language model so that when we process our recognition */
              /* result we'll be able to distinguish it from the rejection word, "???". */
              status = SRSetProperty (gTopLanguageModel, kSRRefCon, &refcon, sizeof (refcon));

              if (!status) {
                      const char *kSimpleStr[] = { "Hello", "Goodbye", "What Time Is It?", NULL };
                      char          **currentStr    = (char **) kSimpleStr;
                      long          refcon                        = kHelloRefCon;

                      /* Add each of the strings in kSimpleStr to the language model, and set the refcon */
                      /* to the index of the string in the kSimpleStr array. Note that SRAddText is a */
                      /* shortcut for calling SRNewPhrase, SRAddLanguageObject, and SRReleaseObject in */
                      /* succession */

                      while (*currentStr && !status) {
                             status = SRAddText (gTopLanguageModel, *currentStr, strlen (*currentStr), refcon++);
                             ++currentStr;
                      }

                      /* Augment this simple language model with a fancier one. */
                      if (!status)
                             status = AddFancierLanguageModel (gTopLanguageModel);
              }
       }

       return status;
}
```

A recognizer returns a special speech object, called the *rejection word*, if it hears an utterance but cannot recognize it. Listing 3 sets the reference constant of the top-level language model to a pre-defined value to be able to distinguish that model from the rejection word.

Note in Listing 3 that we add the phrases “Hello,” “Goodbye,” and “What time is it?” to our gTopLanguageModel using the call SRAddText, a convenient shortcut for the sequence of calls SRNewPhrase, SRAddLanguageObject, and SRReleaseObject. SRAddText also sets the kSRRefCon property of each added phrase. We’ll use this reference constant when we examine the recognition result to help determine what was said.

HANDLING RECOGNITION RESULT NOTIFICATIONS

Listing 4 shows how your application would process result notifications given this simple language model. In the first part of the listing, our Apple event handler, HandleRecognitionDoneAE, uses the routine AEGetParamPtr to extract the status of the result as well as the recognizer and recognition result objects from the Apple event. At this point, it could easily get the text of what was heard by getting the kSRTEXTFormat property of the recognition result. But a more useful form of the result is the kSRLanguageModelFormat. This language model parallels the language model gTopLanguageModel, but instead of containing all of the phrases “Hello,” “Goodbye,” and “What time is it?” it contains only a copy of the phrase that was recognized.

Listing 4.

Processing a recognition result

```
pascal OSErr HandleRecognitionDoneAE (AppleEvent *theAEevt, AppleEvent *reply, long refcon)
{
       OSErr                 recognitionStatus = 0, status;
       long                  actualSize;
       DescType              actualType;

       /* Get recognition result status. */
       status = AEGetParamPtr (theAEevt, keySRSpeechStatus, typeShortInteger, &actualType,
                                                                 (Ptr) &recognitionStatus, sizeof
(recognitionStatus), &actualSize);

       /* Get the SRRecognizer. */
       if (!status && !recognitionStatus) {
              SRRecognizer recognizer;
              status = AEGetParamPtr (theAEevt, keySRRecognizer, typeSRRecognizer, &actualType,
                                                                        (Ptr) &recognizer, sizeof (recognizer),
&actualSize);

              /* Get the SRRecognitionResult. */
              if (!status) {
                     SRRecognitionResult recResult;
                     status = AEGetParamPtr (theAEevt, keySRSpeechResult, typeSRSpeechResult, &actualType,
                                                                        (Ptr) &recResult, sizeof (recResult),
&actualSize);

                     /* Extract the language model from the result. */
                     if (!status) {
                            SRLanguageModel resultLM;
                            long propertySize = sizeof (resultLM);
```

```
                                status = SRGetProperty (recResult, kSRLanguageModelFormat, &resultLM, &propertySize);

                                /* Process the language model. */
                                if (!status) {
                                        ProcessRecognitionResult (resultLM, recognizer);

                                        /* What we SRGot we must SRRelease! */
                                        SRReleaseObject (resultLM);
                                }
                                /* Also release the recognition result. */
                                SRReleaseObject (recResult);
                        }
                }
        }

        /* If recognition went fine, how about the processing? */
        return recognitionStatus ? recognitionStatus : status;
}

OSErr ProcessRecognitionResult (SRLanguageModel resultLM, SRRecognizer recognizer)
{
        OSErr           status = noErr;

        if (resultLM && recognizer) {
                long            refcon;
                long            propertySize = sizeof (refcon);

                status = SRGetProperty (resultLM, kSRRefCon, &refcon, &propertySize);

                /* Is the resultLM a subset of our top language model or is */
                /* it the rejection word, "???"? */
                if (!status && refcon == kTopLMRefcon) {
                        SRLanguageObject languageObject;
                        propertySize = sizeof (languageObject);

                        /* The resultLM contains either an SRPath or an SRPhrase.  We use the refcon */
                        /* property set in our language model building routines to distinguish between */
                        /* the results. */

                        /* We expect our result language model to contain only one item, a phrase or a */
                        /* path; get it. */
                        status = SRGetIndexedItem (resultLM, &languageObject, 0);

                        if (!status) {
                                long refcon;
                                propertySize = sizeof (refcon);

                                /* Get the refcon of the object at the root of our language model. */
                                status = SRGetProperty (languageObject, kSRRefCon, &refcon, &propertySize);

                                if (!status) switch (refcon) {
                                        case kHelloRefCon:
                                        case kGoodbyeRefCon:
```

```
                    case kWhatTimeIsItRefCon:
                        {
                            const char *kResponses[] =
                                {   "Hi There!", "Don't leave now!",
                                    "It's time to use the Speech Recognition
Manager!" };

                            /* Speak and display our response using the feedback character.
Use */
                            /* the refcon as an index into our response array. */
                            status = SRSpeakAndDrawText (recognizer, kResponses[refcon],
                                                    strlen
(kResponses[refcon]));
                        }
                        break;
                    case kCompanyRefCon:
                        status = ProcessFancierLanguageModel (languageObject, recognizer);
                        break;
                }

                /* Always SRRelease what we SRGot. */
                status = SRReleaseObject (languageObject);
            }
        }
    }

    return status;
}
```

For example, if the user said “Goodbye,” the language model returned in the kSRLanguageModelFormat property would contain one phrase, which would have a kSRSpelling property of Goodbye and a kSRRefCon property of 1 (the value passed for that phrase in the SRAddText call in Listing 3). ProcessRecognitionResult uses the language model to determine what was said by getting the kSRRefCon property of the spoken phrase and responding appropriately.

This example uses the SRSpeakAndDrawText routine to respond to recognition events. The Speech Recognition Manager uses the Speech Synthesis Manager to speak the string, and the animated feedback character (displayed in Apple’s standard feedback window) lip-synchs with the synthesized text. The Speech Recognition Manager also displays the response text in the feedback window. (You can use other routines to simply speak a string through the feedback window without displaying it, or to display a string without speaking it.)

SETTING THE ACTIVE LANGUAGE MODEL AND STARTING TO LISTEN

All we need to do now is make the language model we’ve built, gTopLanguageModel, the *active* language model. We do this by calling the SRSetLanguageModel function, which associates gTopLanguageModel with the SRRecognizer we’ve allocated, gRecognizer:

```
OSErr status = SRSetLanguageModel(gRecognizer,
               gTopLanguageModel);
```

You can build as many language models as you like, but there is always just one that’s active. You can make another language model active (and thereby deactivate the one that was previously active), or you can enable and disable parts of the active language model.

Once we’ve set the active language model, we start the recognition process by calling SRStartListening, as follows:

```
if (!status)
        status = SRStartListening(gRecognizer);
```

Now we can start speaking to our application. When an utterance is recognized as belonging to our language model, our Apple event handler, HandleRecognitionDoneAE, will be called and the recognition result will be processed. It’s that easy!

CLEANING UP

Listing 5 shows how to clean up when your application quits. In general, you should release the speech objects in the order shown.

Listing 5.
Terminating speech recognition

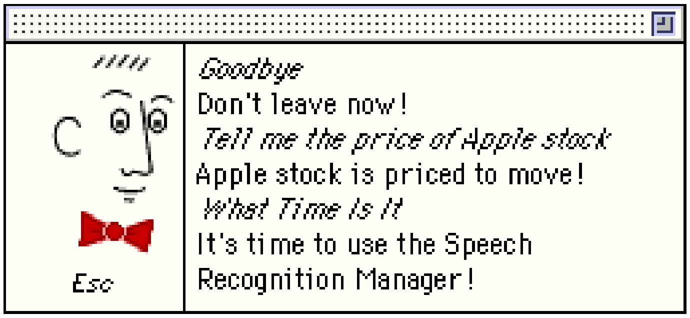
```
OSErr TerminateSpeechRecognition (void)
{
        OSErr status = noErr;

        /* If we have a top-level language model, release it. */
        if (gTopLanguageModel) {
                status = SRReleaseObject (gTopLanguageModel);
                gTopLanguageModel = NULL;
        }

        /* If we have a recognizer, release it. */
        if (gRecognizer) {
                status = SRStopListening (gRecognizer);
                status = SRReleaseObject (gRecognizer);
                gRecognizer = NULL;
        }

        /* If we have a recognition system, close it. */
        if (gRecognitionSystem) {
                status = SRCloseRecognitionSystem (gRecognitionSystem);
                gRecognitionSystem = NULL;
        }

        /* Remove our Apple event handler and dispose of the handler's routine descriptor. */
        if (gAERoutineDescriptor) {
                status = AERemoveEventHandler (kAESpeechSuite, kAESpeechDone, gAERoutineDescriptor, false);
                DisposeRoutineDescriptor (gAERoutineDescriptor);
                gAERoutineDescriptor = NULL;
        }

        return status;
}
```

SPEECH RECOGNITION TIPS

Speech recognition is a completely new input mode, and using it properly isn’t always as straightforward as it might seem. While we don’t yet have a complete set of human interface guidelines to guarantee a consistent and intuitive speech recognition user experience, there are a few simple rules that all speech recognition applications should follow.

GIVE FEEDBACK

Your application must always provide feedback to let users know when they can speak, when their utterance has been recognized, and how it was interpreted. The feedback services in the Speech Recognition Manager perform this for you, using the standard feedback window shown in Figure 3. (The user’s recognized utterances are shown in italics, and the displayed feedback is in roman text. The string under the feedback character’s face indicates the push-to-talk key.) All you need to do is set the kSRFeedbackAndListeningModes property as shown in Listing 2.



Goodbye
Don't leave now!
Tell me the price of Apple stock
Apple stock is priced to move!
What Time is It
It's time to use the Speech Recognition Manager!

Figure 3.
Standard feedback window

Your application should use this standard feedback behavior unless you have a *very* good reason to provide your own feedback and custom push-to-talk options. (Fast action games that take over the entire screen and don’t call WaitNextEvent are examples of applications that wouldn’t use the standard feedback.) Not only will users enjoy the benefits of consistent behavior, but as Apple improves the feedback components, your speech recognition applications will automatically inherit this improved behavior without having to be recompiled.

SHOW WHAT CAN BE SAID

Successful speech recognition applications always let the user know what he or she can say. The way they achieve this depends on the application, but one good example is a Web browser that makes all visible hyperlinks speakable. This lets the user know what can be said while restricting the size of the language model to improve recognition accuracy.

BE CLEAR AND COMPLETE

The recognition technology currently used by the Speech Recognition Manager works best when it’s listening for a small number of distinct utterances. The longer an utterance is, the more easily it can be distinguished from other utterances. For example, distinguishing the isolated words *hot*, *cut*, and *quit* is difficult and error prone. Recognition performance also decreases as the language model grows. The larger the language model, the more time the recognizer must spend searching for a matching utterance and the larger the likelihood of two utterances in the language model sounding similar. For best results, limit the size of the language model to fewer than a hundred phrases at any time and avoid including phrases that are easily confused when spoken, like “wreck a nice beach” and “recognize speech.”

DO SOMETHING DIFFERENT

Compelling applications of speech recognition are often novel ones. Instead of simply paralleling an application’s graphical user interface with a spoken one (making all menu items speakable, for example), do something different — something that takes advantage of the unique properties of speech. Combine speech synthesis with speech recognition to engage the user in a brief dialog. Use efficient language models to allow a single utterance to trigger a series of commands that might otherwise require interaction with dialog boxes. Use the power of speech recognition to augment the graphical interface your users are already so familiar with. Above all, use your imagination.

BUILDING FANCIER LANGUAGE MODELS

The Speech Recognition Manager provides a large number of routines that your application can use to create and manipulate fancier language models than the one created earlier in Listing 3. For example, suppose you wanted to create an application that responds to users when they say “Tell me the price of <company> stock,” where <company> is one of several company names.

To create a language model like this, your application needs to create an SRPath object that consists of the phrase “Tell me the price of” followed by an *embedded* language model representing the company names, followed by the word “stock.” The AddFancierLanguageModel function (not shown, but included on the accompanying CD) creates this path and adds it to the language model created in Listing 3. (Note that the embedded company language model is simply a list of phrases, just like the language model we created in Listing 3.)

Figure 4 shows the structure of the entire language model. We’ve limited the number of companies to three here for simplicity. The top half of each box shows the spelling and refcon properties of each object; the lower half indicates the object type.

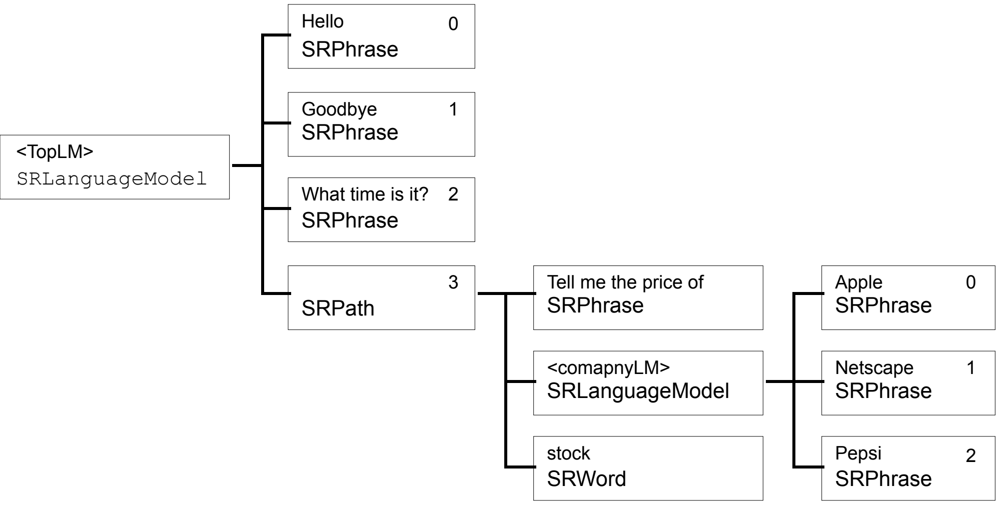


Figure 4.
Language model built by calling BuildLanguageModel

Take a look at the code on the CD to see how to build the fancier language model. Don’t worry if it seems like a lot of code to write just to add the command “Tell me the price of <company> stock.” Below we’ll describe a tool that can make the creation of complicated static language models very easy. Listing 6 shows how your application would process results given this fancier language model.

Listing 6.

Processing an SRPath result as built by AddFancierLanguageModel

```
OSErr ProcessFancierLanguageModel (SRPath resultPath, SRRecognizer recognizer)
{
        OSErr           status = noErr;

        if (resultPath && recognizer) {
                SRLanguageModel companyLM;

                /* Get the second item in the path — it's the company language model. */
                status = SRGetIndexedItem (resultPath, &companyLM, 1);

                if (!status && companyLM) {
                        SRPhrase companyName;

                        /* The company language model contains just one phrase. */
                        status = SRGetIndexedItem (companyLM, &companyName, 0);

                        if (!status) {
                                long    refcon;
                                long    propertySize = sizeof (refcon);

                                /* Get the refcon from the company name. It's our index into the response array. */
                                status = SRGetProperty (companyName, kSRRefCon, &refcon, &propertySize);
                                if (!status) {
                                        const char *kResponses[] =
                                                                {       "Apple stock is priced to move!",
                                                                        "Netscape is trading at fifty dollars.",
                                                                        "Why would you want to know that?"
                                                                };

                                        status = SRSpeakAndDrawText (recognizer, kResponses[refcon],
                                                                                                        strlen
(kResponses[refcon]));
                                }
                                /* What we SRGot we must SRRelease. */
                                status = SRReleaseObject (companyName);
                        }
                        status = SRReleaseObject (companyLM);
                }
        }
        return status;
}
```

Speech recognition applications that support utterances like “Tell me the price of <company> stock” or “Call <name>,” while limiting <company> or <name> to a few dozen items, can be more compelling than those that just respond to simple phrases. They are nicely limited in scope, yet they allow the user to invoke actions more easily than they could with a graphical user interface. What other technology does that?

MANIPULATING LANGUAGE MODELS

The Speech Recognition Manager contains several more routines and properties for manipulating language models. We’ll look at a few of them here.

Your application can create a large language model and then use the SRSetProperty function to disable and enable parts of it quickly on the fly, as shown in Listing 7. By enabling only parts of a language model, you can minimize the number of utterances that the recognizer is listening for.

Listing 7.

Disabling a part of a language model

```
/* Disable the stockPath part of the gTopLanguageModel. The stock path is the fourth */
/* item in this LM. */

SRPath        stockPath;
OSErr  status = SRGetIndexedItem (gTopLanguageModel, &stockPath, 3);

if (!status) {
       Boolean enabled = false;
       status = SRSetProperty (stockPath, kSREnabled, &enabled, sizeof (enabled));
       SRReleaseObject (stockPath);
}
```

Your application can change, clear, or rebuild parts of a language model dynamically to reflect the current context of your program. Listing 8 clears and then rebuilds the company language model that was originally built by the AddFancierLanguageModel function.

Listing 8.

Emptying and refilling the <company> language model

```
/* Empty and refill the embedded <company> language model. Assume that stockPath is */
/* initialized. The companyLM is the second item in the stockPath. */

SRLanguageModel      companyLM;
OSErr                       status = SRGetIndexedItem (stockPath, &companyLM, 1);

if (!status) {
       /* This releases each phrase in the company language model. */
       status = SREmptyLanguageObject (companyLM);
```

```
        /* Now rebuild the company language model with new companies. */
        if (!status) {
                const char      *kNewCompanies[]        = {     "I B M", "Motorola", "Coca Cola", NULL };
                char                    **company                       = (char **) kNewCompanies;
                long                    refcon                          = 0;

                while (*company && !status) {
                        status = SRAddText (companyLM, *company, strlen (*company), refcon++);
                        ++company;
                }
        }
        SRReleaseObject (companyLM);
}
```

At any given moment, the active language model should be relatively small, but your application can change the set of active phrases at any moment. For example, if a Web browser application made its links speakable, at any given moment there would only be a few dozen visible links, so there would only be a few dozen phrases active. But if you spent a couple of hours surfing the Web with that browser, you would have seen many thousands of links throughout the session, and you could have spoken any one of them while it was visible.

In addition to enabling and disabling parts of your language model, the SRSetProperty function allows your application to make words, phrases, paths, or language models repeatable (so that the user can say that item one or more times in a row) or rejectable (so that if the user says something else for that item, the recognizer will fill it in with a special rejection word with a spelling of “???”).

Your application can also make any word, phrase, path, or language model optional by setting the corresponding object’s kSROptional property to true. In AddFancierLanguageModel, we’ve set the kSROptional property of the SRWord “stock” to true, so the recognizer is ready for the user to say “Tell me the price of Apple” as well as “Tell me the price of Apple stock.”

Your application doesn’t have to build language models from scratch each time it runs. The Speech Recognition Manager provides routines for saving and loading language objects (for example, SRPutLanguageObjectIntoHandle and SRNewLanguageObjectFromDataFile). Listing 9 shows how you can use these.

Listing 9.

Saving a language model into a resource

```
/* Allocate a Handle of size 0 to store our language model in; SRPutLanguageObjectIntoHandle */
/* will resize it as needed. */
Handle lmHandle      = NewHandle (0);
OSErr  status = MemError ();

if (!status) {
        status = SRPutLanguageObjectIntoHandle (gTopLanguageModel, lmHandle);
```

```
    if (!status) {
        /* Save the language model as a resource in the current resource file. Pick a */
        /* reasonable resource type and ID. */
        AddResource (lmHandle, 'LMDL', 100, "\pTop Language Model");

        /* Make sure it gets written to disk. */
        if (!(status = ResError ()))
            WriteResource (lmHandle);
    }

    DisposeHandle (lmHandle);
}
```

Apple provides a handy developer tool, called SRLanguageModeler, for quickly creating, testing, and saving language models into resources or data files. This tool is provided with other Speech Recognition Manager developer information and lets you create language models by writing them out in text form. SRLanguageModeler then lets you try out the language model in a real recognition scenario to see how well its phrases can be recognized and discriminated from one another. Once you save the language models into a binary resource or file format, they can be reloaded into your application using either the routine SRNewLanguageObjectFromHandle or the routine SRNewLanguageObjectFromDataFile, respectively. Unless the content of your language models changes dynamically during the execution of your program, SRLanguageModeler will eliminate the code you would otherwise have to write to construct your language models.

SPEECH: THE FINAL FRONTIER

If you've grokked this article, you'll have no problem making practical use of speech recognition in your application. From the basics of checking for the proper version of the Speech Recognition Manager to some of the finer details of building language models, we've shown you everything you need to know to get started. Take a look at the SRSample application on the accompanying CD, which uses many of the listings in this article. To dig even deeper, check out the *Inside Macintosh* chapter "Speech Recognition Manager" and the SRLanguageModeler tool, also on the CD. Finally, keep an eye on our website at **www.speech.apple.com** for the latest versions of Apple's speech recognition software, tools and sample code.

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