The Hiwire Database

R E A D M E

1. Introduction

This database has been collected and packaged under the auspices of the IST-EU STREP project HIWIRE [1,2] (Human Input that Works In Real Environments). The database was designed to be used as a tool for development and test of speech processing and recognition techniques dealing with robust non-native speech recognition.

The database contains 8100 English utterances pronounced by non-native speakers (31 French, 20 Greek, 20 Italian, and 10 Spanish speakers. The collected utterances correspond to human input in a command and control aeronautics application. The data was recorded in studio with a close-talking microphone and real noise recorded in an airplane cockpit was artificially added to the data. The signals are provided in clean (studio recordings with close talking microphone), low, mid and high noise conditions. The three noise levels correspond approximately to signal-to-noise ratios of 10dB, 5dB and -5 dB respectively.

The database does not provide training material. TIMIT [3] database is suggested for training the required acoustic models. Two different evaluation tasks are defined:

1) Robust non-native task (RNN)
In this task, all clean and noisy speech utterances are used. The purpose of this task is the evaluation of feature extraction and (unsupervised) feature transformations.

2) Non-native adaptation task (NNA)
In this second task, data has been spited into adaptation and test (50% of each speaker utterances are in the adaptation set and the remaining 50% utterances are in the test set). The purpose of this task is the evaluation of acoustic modeling and model adaptation algorithms to deal with non-native speech input. Both clean and noisy test data can be used in this second task.

A reference recognizer setup based on HTK [4] is also provided along with reference baseline results for the two defined tasks.

2. Audio data

Clean audio data has been recorded in a studio using a close-talking microphone (Plantronics USB-45). The used sampling frequency is 16 kHz and data is stored in Windows PCM WAV 16 bits mono format.

Recordings correspond to prompts extracted from an aeronautic command and control application (The full listing can be found in Annex 2). A total of 8099 utterances have been recorded corresponding to 81 speakers pronouncing 100 utterances each. The speaker distribution is as follows:

Country	# Speakers	# Utterances
France	31	3100
Greece	20	2000
Italy	20	2000
Spain	10	999
Total	*81*	*8099*

2.1. Noise addition

Noisy data is generated by artificial addition of real noise recorded into a Boeing 737 cockpit with a boundary microphone (AKG Q300) located at the dashboard of the cockpit. The noise has been recorded during normal cruise and is quite stationary. Figure 1 shows the time domain and average power spectrum of the noise.

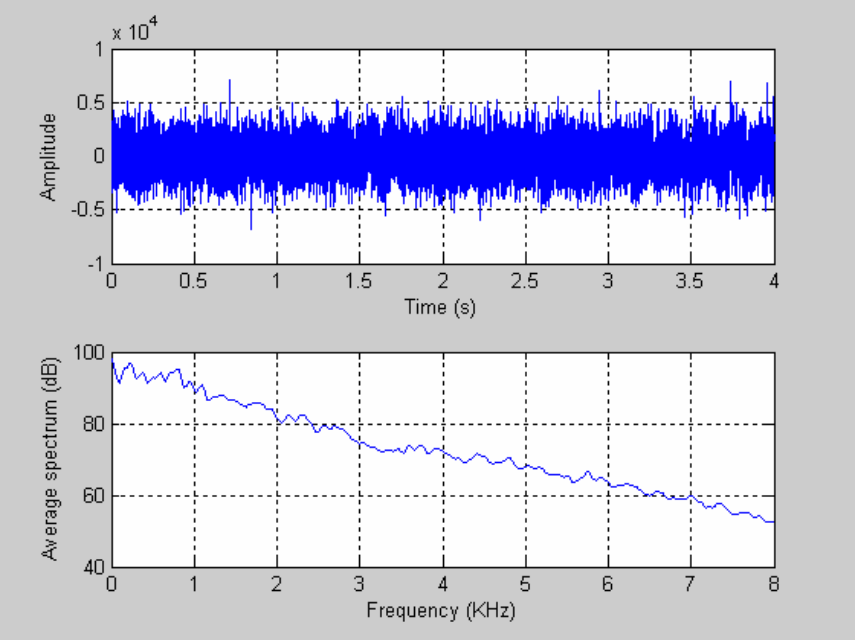

Figure 1. Time domain plot and average spectrum of the noise.

To generate the noisy data utterances, the speech level is maintained and only the noise amplitude is modified to obtain the desired SNR. The noise amplitude is adjusted to obtain three different averaged SNR values of 10dB, 5dB and -5dB which are referenced in this document as low noise (LN), mid noise (MN) and high noise (HN) conditions. For each given condition the noise level remains constant.

2.2. File location

The speech data files are organized in a three level directory structure under the **speechdata** directory of the DVD.

```
speechdata
\---Noise_Condition                                    (1st level)
    \---Language                                       (2nd level)
        \---Speaker                                    (3rd level)
            \---files.wav
```

1/ The first level is related to the four noise conditions

- clean
- High noise (HN), average SNR = -5dB
- Medium noise (MN), average SNR = 5dB
- Low noise (LN), average SNR = 10dB

```
speechdata
+---clean
+---HN
+---LN
\---MN
```

2/ The second level is about the speakers' nationality:

- French (FR)
- Greek (GR)
- Italian (IT)
- Spanish (SP)

```
speechdata
+---clean
|   +---FR
|   +---GR
|   +---IT
|   \---SP
+---HN
|   +---FR
|   ...
...
```

3/ The third and last directory level is about the speaker who is referred by four letters:

- the first is the nationality (F, G, I or S)
- the second and third are the person's initials
- the last is the gender (F for female and M for male)

```
speechdata
+---clean
|    +---FR
|    |    +---FABF
|    |    +---FACF
|    |    +--- ...*
|    |    \---FVCM
|    +---GR
|    |    +---GAKF
|    |    +--- ...
|    |    \---GVSF
|    +---IT
|    |    +---IABM
|    |    +--- ...
|    |    \---IVSF
|    \---SP
|         +---SARM
|         +--- ...
|         \---SMCM                                  * The whole list of speakers is in
+--- ...                                           Annex 1 at the end of this document.
```

4/ At this level, *.wav files can be found. Their names are composed by the speaker directory, the sentence number and the noise condition (empty if clean).

For example, the following file is the sentence #159 pronounced by an Italian (`I`) woman (`F`) whose initials are AN, in low noise condition:

```
IANF_159_LN.wav
```

In the same directory, a file sums up some information about the speaker ("Speaker_infos.txt") and one other gives the sentences pronounced ("list.txt").

A number of 331 different prompts are used in the recordings. The whole set of prompts is listed in the Annex 2 of this document.

3. The reference recognizer

A reference recognizer setup based on HTK is located under the **HTK_setup** directory with the following structure.

```
HTK_setup
+---lib
+---lists
+---MODELS
+---ref_results
\---scripts
```

The **lists** directory contains the lists of utterances for the different evaluation sets (adaptation and test). The **lib** directory contains the grammar definition, the utterance transcriptions and configuration files for HTK scripts. The **scripts** directory contains scripts for running the reference tests. The **MODELS** directory contains acoustic models trained using TIMIT training data. Finally, the **ref_results** directory contains reference results for each of the recognition tasks.

3.1. Language model and transcriptions

The information related to the language model is stored in the **lib** directory.
A finite state grammar is used as the language model for the recognition tasks. The grammar definition can be found in Annex 3 of this document and is also available in the file **hiwire.gram**. The perplexity of the grammar is 14,9 and the vocabulary contains 133 words. A dictionary containing all the 133 words along with its phone transcriptions is supplied in the **hiwire.dic** file under the same directory.

Transcriptions of all the utterances in the database are provided in the files **hiwire.mlf**, **hiwire_LN.mlf**, **hiwire_MN.mlf** and **hiwire_HN.mlf**. These files are used for result analysis and MLLR supervised adaptation (see below).

3.2. Basic feature extraction

Basic feature extraction used to obtain the reference results is based on HTK (**HCopy** is used). A configuration file (**config_hcopy**) is provided in the **lib** directory.

The parameterization used for the baseline results is MFCC containing 12 cepstral coefficients and C0.
The coefficients are extracted using a 24 channels triangular filter bank. Cepstral man subtraction (CMS) is used for basic feature normalization. During decoding, the feature vector is augmented with its first and second regression coefficients (Delta and Acceleration parameters as computed by HTK).

A pair of SHELL scripts (**docode.csh**, **work_code.csh**) is provided to perform feature extraction. The scripts can be easily modified to run other feature extraction algorithms. Running **work_code.csh**, creates the **code** directory under the **HTK_setup** directory containing the feature files of all utterances in the database.

3.3. Pre trained models

Pre trained TIMIT acoustic models are provided under the **MODELS** directory. These are context free, 3 state phone models built using the basic feature extraction describe above. Models for 32, 64, 128 and 256 Gaussian mixtures are provided along with the corresponding stat files (as produced by **HERest**). For each number of Gaussians, two files are provided. The first one (**mix*nnn*_hmms**) contains the raw models, while the second one (**mix*nnn*_hmms_rc32**) also contains a 32 regression class tree used for MLLR adaptation.

3.4. Evaluation tasks

A set of files is provided under the **lists** directory containing the files needed for the evaluation of the two defined recognition tasks. The organization is as follows:

For each language (FR, GR, IT, SP), a file that contains the speaker names is located in the lists directory under the name **LL.spkrs** where **LL** is the codename of the language.

A file containing the whole set of utterances for all the speakers in a given language, named **all_LL.list**, is also provided (where **LL** is the codename of the language).

For each speaker, two files are provided: **adap_XXXX.list** and **test_XXXX.list** where **XXXX** is the codename of the speaker (see section 2.1). The first file the speaker adaptation data (half of the utterances) and the second one contains the test data (the other half).

3.4.1. Robust non-native task (RNN)

For this task, recognition results must be provided for the whole speech material of the database. Therefore, both adaptation and test data files for the speakers are used in this task. The SHELL script **work_eval1.csh** can be used for this purpose. Running this script will generate a set of files containing the recognition results. The files with **.mlf** extension are the lattice generated by **HVite** and files with the **.results** extension contains the statistics as computed by **HResults**. Filenames are encoded as follows:

```
NOISE_LANG_SET.[mlf|results]

NOISE = clean|LN|MN|HN
LANG  = FR|GR|IT|SP
SET   = adap|test
```

Along with these files, global statistics are computed for all data (adap and test) for each language and stored in a set of files named

```
NOISE_LANG_all.results
```

And averaged results for all languages are computed and stored in a set of files named

```
NOISE_all.results
```

To be used as reference for the non-native adaptation task, result files for the clean test data alone are also produced with names

```
clean_LANG_test.results
clean_test.results
```

3.4.2. Non-native adaptation task (NNA)

For this second task, results must be provided only for the files on the test partition of the database (onlcy clean test data or both clean and noisy test data).
The SHELL script **dotest_mllr.csh** can be used to perform MLLR adaptation and decoding of a given speaker test data in a given noise condition. It is called as

```
dotest_mllr.csh NOISE LANG NADAP
NOISE = clean|LN|MN|HN
LANG  = FR|GR|IT|SP
NADAP = adaptation utterances (from 1 to 50)
```

Where **NOISE** is the noise condition, **LANG** specifies the language and **NADAP** is used to fix the number of adaptation utterances to be used. For each speaker, the script performs MLLR supervised adaptation in the following way:

1) A global MLLR transformation is first computed using forced alignment of a subset of the adaptation utterances of a given speaker.
2) This global transformation is then used to obtain a more powerful MLLR transformation using a 32 class regression tree. This is done again by forced alignment using the previous transformation.
3) Finally, test data for the speaker is decoded using this last transformation.

For obtaining the clean test results, the script **work_eval2.csh** can be used. Running this script will create a set of files with names of the form.

```
clean_LANG_test_mllr_NADAP.[mlf|results]

LANG  = FR|GR|IT|SP
NADAP = 50|20|10
```

containing the results for the clean test partition of the database. Averaged results are also obtained for each adaptation size containing results for all the languages, and stored in the set of files

```
clean_test_mllr_NADAP.results
```

It is also possible to perform simultaneous speaker and noise adaptation by selecting a noise condition different from **clean** in **dotest_mllr.csh**. The script **work_eval3.csh** performs simultaneous speaker and noise adaptation using 50 utterances per speaker. The output file names are of the form

```
NOISE_LANG_test_mllr_50.[mlf|results]
```

and contain speaker and noise adaptation results for each noise condition and language. Averaged results are also obtained for each noise condition containing results for all the languages, and stored in the set of files with names

```
NOISE_test_mllr_50.results
```

Note: The files containing computed MLLR transformations are stored in the **ref_results/tfms** directory with filenames of the form

```
TYPE_NOISE_SPEAKER_NADAP.tfm

TYPE   = GLOBAL|RC
NOISE  = clean|LN|MN|HM
SPEKAR = speaker codename
NADAP  = number of adaptation utterances
```

Remarks:

1) The adaptation scripts (**`dotest_mllr.csh`**) only work with HTK versions up to v3.2.1.

2) The directory where the HTK binaries reside should be added in the environment's PATH.

3) Depending on the Linux version that is used it might be necessary to consider the following modifications:

   a. It might be necessary to rewrite the sed commands in the scripts as follows:

      Originally: **`sed -e "sW$DIRTIMIT/WW" aa`**

      Corrected: **`sed -e "s_${DIRTIMIT}/__" aa`**

      The above (replace each W with underscore (_)) applies to all **`sed`** commands in the scripts.

   b. Avoid setting a **`$DIRTIMIT`** path having an underscore (_) in it.

   c. The script that constructs the mlf tables might insert two dummy lines in the beginning of the file which must be removed.

d.

4. Baseline results

Baseline results for the two different evaluation tasks are reported in this section. Results are obtained using the scripts described in the previous section, and are available in the **ref_results** directory. All reference results have been obtained using the 128 Gaussian mixture models in the **MODELS** directory.

4.1. Robust non-native task (RNN)

These results correspond to the test set only. Adaptation set results can be found in the **ref_results** directory. Different columns correspond to the native language (**Nat Lang**), the number of sentences (**#Sent**), the percent of correct words (**Corr**), the substitution (**Sub**), Deletion (**Del**) and Insertion (**Ins**) errors, the word error rate (**Err**) and the sentence error rate (**S. Err**). First four rows show averaged results obtained with the full set of utterances of each language (these can be found in the files **NOISE_LANG_all.results**). Last row shows the global averaged results considering all languages (these results can be found in the files **NOISE_all.results**). Results have been obtained using **work_eval1.csh** script.

Clean results

Nat Lang	#Sent	Corr	Sub	Del	Ins	Err	S. Err
French	3099	93,58	5,67	0,75	0,54	6,96	14,97
Greek	2000	91,99	7,29	0,72	2,16	10,17	20,25
Italian	1983	91,25	7,92	0,83	2,60	11,35	21,13
Spanish	999	92,81	6,04	1,15	0,56	7,74	16,92
Sum/Avg	**8081**	**92,51**	**6,68**	**0,81**	**1,46**	**8,95**	**18,03**

Low Noise results

Nat Lang	#Sent	Corr	Sub	Del	Ins	Err	S. Err
French	3099	37,08	30,83	32,10	0,52	63,45	71,83
Greek	2000	50,13	30,13	19,74	1,15	51,02	67,05
Italian	1983	49,36	26,39	24,25	1,26	51,90	61,02
Spanish	999	57,58	25,72	16,70	0,66	43,08	57,86
Sum/Avg	**8081**	**45,96**	**28,91**	**25,13**	**0,88**	**54,92**	**66,27**

Mid Noise results

Nat Lang	#Sent	Corr	Sub	Del	Ins	Err	S. Err
French	3099	15,58	32,34	52,08	0,16	84,58	86,77
Greek	2000	24,18	33,52	42,30	0,84	76,65	84,40
Italian	1983	29,90	30,28	39,82	0,65	70,75	77,41
Spanish	999	31,73	29,92	38,35	0,39	68,67	76,28
Sum/Avg	**8081**	**23,31**	**31,82**	**44,87**	**0,48**	**77,17**	**82,59**

High Noise results

Nat Lang	#Sent	Corr	Sub	Del	Ins	Err	S. Err
French	3099	2,13	32,95	64,92	0,01	97,88	97,61
Greek	2000	1,02	32,27	66,71	0,02	99,00	98,55
Italian	1983	3,56	32,62	63,82	0,08	96,52	96,32
Spanish	999	1,71	31,50	66,80	0,00	98,29	97,40
Sum/Avg	**8081**	**2,15**	**32,51**	**65,33**	**0,03**	**97,88**	**97,50**

4.2. Non-native adaptation task (NNA)

In this section, results for the model adaptation task are presented. Two set of results are provided. The first one corresponds to clean test adaptation using 50, 20 and 10 utterances per speaker. The second one corresponds to simultaneous speaker and noise adaptation using 50 utterances per speaker. MLLR adaptation is performed using a 32 class regression tree.

4.2.1. Clean test speaker adaptation results

In the following tables, results for the clean data test set using adaptation sizes of 50, 20 and 10 utterances respectively are shown. First four rows show averaged results obtained with the utterances in the test set of each language (these can be found in the files **`clean_LANG_test_mllr_NADAP.results`**). Last row shows the global averaged results considering all languages (these results can be found in the files **`clean_test_mllr_NADAP.results`**). Results have been obtained using **`work_eval2.csh`** script.

Clean test results, 50 utterances adaptation

Nat Lang	#Sent	Corr	Sub	Del	Ins	Err	S. Err
French	1549	97,68	2,10	0,23	0,16	2,48	5,94
Greek	1000	98,28	1,59	0,13	0,20	1,92	4,90
Italian	990	97,08	2,62	0,30	0,86	3,78	8,69
Spanish	499	97,15	1,92	0,93	0,33	3,18	6,01
Sum/Avg	**4038**	**97,61**	**2,08**	**0,31**	**0,37**	**2,75**	**6,36**

Clean test results, 20 utterances adaptation

Nat Lang	#Sent	Corr	Sub	Del	Ins	Err	S. Err
French	1549	97,03	2,68	0,29	0,11	3,09	7,42
Greek	1000	97,62	2,12	0,26	0,33	2,71	6,70
Italian	990	95,29	4,18	0,53	0,86	5,58	12,32
Spanish	499	96,09	3,05	0,86	0,13	4,04	9,42
Sum/Avg	**4038**	**96,62**	**2,96**	**0,42**	**0,36**	**3,74**	**8,69**

Clean test results, 10 utterances adaptation

Nat Lang	#Sent	Corr	Sub	Del	Ins	Err	S. Err
French	1549	96,31	3,22	0,47	0,16	3,85	8,84
Greek	1000	96,96	2,81	0,23	0,43	3,47	8,40
Italian	990	94,99	4,48	0,53	0,93	5,94	13,03
Spanish	499	95,29	3,64	1,06	0,13	4,84	10,42
Sum/Avg	**4038**	**96,01**	**3,49**	**0,50**	**0,42**	**4,41**	**9,96**

For reference, this last table shows results for the test data set without adaptation (results can be obtained from files **`clean_LANG_test.results`** and **`clean_test.results`**).

Clean test results without adaptation

Nat Lang	#Sent	Corr	Sub	Del	Ins	Err	S. Err
French	1549	94,21	5,05	0,74	0,41	6,20	12,85
Greek	1000	92,40	6,97	0,63	2,21	9,81	19,40
Italian	990	91,53	7,70	0,76	2,79	11,25	21,21
Spanish	499	92,64	6,36	0,99	0,73	8,08	17,43
Sum/Avg	**4038**	**92,88**	**6,37**	**0,75**	**1,50**	**8,62**	**17,09**

4.2.2. Noisy tests with simultaneous speaker and noise adaptation results

Results for simultaneous speaker and noise adaptation results are shown in the following tables for an adaptation size of 50 utterances (results can be obtained from files **`NOISE_LANG_test_mllr_50.results`** and **`NOISE_test_mllr_50.results`**) and have been obtained using **`work_eval3.csh`** script

Low Noise test results, 50 utterances adaptation

Nat Lang	#Sent	Corr	Sub	Del	Ins	Err	S. Err
French	1549	64,79	18,81	16,40	0,23	35,44	47,06
Greek	1000	72,67	16,29	11,04	0,36	27,69	41,40
Italian	990	76,13	13,98	9,89	0,50	24,37	36,16
Spanish	499	80,98	12,19	6,83	0,27	19,28	31,66
Sum/Avg	**4038**	**71,67**	**16,13**	**12,21**	**0,33**	**28,67**	**41,08**

Mid Noise test results, 50 utterances adaptation

Nat Lang	#Sent	Corr	Sub	Del	Ins	Err	S. Err
French	1549	34,20	28,07	37,73	0,20	66,01	74,05
Greek	1000	46,20	26,70	27,10	0,36	54,16	69,50
Italian	990	54,78	21,55	23,67	0,23	45,45	56,57
Spanish	499	57,72	21,54	20,74	0,46	42,74	56,91
Sum/Avg	**4038**	**45,36**	**25,26**	**29,38**	**0,28**	**54,92**	**66,52**

High Noise test results, 50 utterances adaptation

Nat Lang	#Sent	Corr	Sub	Del	Ins	Err	S. Err
French	1549	3,87	33,39	62,74	0,00	96,13	95,67
Greek	1000	3,44	33,11	63,45	0,10	96,66	97,20
Italian	990	12,25	32,14	55,61	0,17	87,92	91,92
Spanish	499	7,62	30,62	61,76	0,13	92,51	93,19
Sum/Avg	**4038**	**6,34**	**32,65**	**61,00**	**0,08**	**93,74**	**94,82**

5. Building new acoustic models

Changing the feature extraction algorithm will require to build a new set of acoustic models. As explained above, TIMIT database is suggested to be used for training. A simple HTK setup is provided in the **TIMIT_Train_hiwire** directory. This setup was used to build the acoustic models used in obtaining the baseline results shown in the previous section.

The script **doall** can be used to build the acoustic models from scratch. This script first builds the required list files, then performs feature extraction and finally calls **dotrain.sh** script to build the models. When using the default HTK based MFCC feature extraction algorithm, only two global variables must be adjusted. The **DIRTIMIT** variable must be modified in the **doall** script to point to the directory containing TIMIT database. The **HTKBIN** variable must be modified in the **doall** and **dotrain.sh** scripts to point to the directory containing HTK executables.

Running **doall** will create two directories **MFCC** and **models**, the first one containing the feature vectors and the second one containing the acoustic models. The directory layout after running **doall** is like the one shown below. Each **hmmXXX** directory contains three files: **hmmdefs** (hmm models), **stats** (statistics collected by HERest) and **vFloors**.

```
TIMIT_Train_hiwire
+---MFCC
    +---train
    \---test
\---models
    +---hmm0
    +---hmm1
    +---hmm2
    +---hmm4
    +--- ...
    +---hmm64
    +---hmm128
    \---hmm256
```

The **dotrain.sh** script also performs phone recognition to check the performance of each set of acoustic models. Results are stored in the **results.txt** file.

To change the default feature extraction, several modifications must be made. The **proto** and **config.parming** files must be changed to reflect the new feature vector structure, and/or the **doall** script must be modified to replace the HTK based feature extraction. This can be easily done replacing the following lines of the script

```
# MODIFY HERE TO CHANGE THE PARAMETERIZATION PROGRAMM
$HTKBIN/HCopy -C $CONFIG  $DIRTIMIT/$i $DIRDEST/$dir/$name.mfc
```

6. References

[1] EU-IST HIWIRE project web site: http://www.hiwire.org

[2] A. Potamianos, G. Bouselmi, D. Dimitriadis, D, Fohr, R. Gemello, I. Illina, F. Mana, P. Maragos, M. Matassoni, V. Pitsikalis, J. Ramírez, E. Sánchez-Soto, J.C. Segura and P. Swaizer, "Towards Speaker and Environmental Robustness in ASR: The HIWIRE project", in *Proc. Workshop on Speech Recognition and intrinsic Variation*, Toulouse (Franse), May 2006.

[3] John S. Garofolo, et al. "TIMIT Acoustic-Phonetic Continuous Speech Corpus", *Linguistic Data Consortium*, Philadelphia, 1993 (http://www.ldc.upenn.edu)

[4] Steve Young, Gunnar Evermann, Mark Gales, Thomas Hain, Dan Kershaw, Gareth Moore, Julian Odell, Dave Ollason, Dan Povey, Valtcho Valtchev, Phil Woodland, "The HTK Book (for HTK Version 3.3)", 1995-1999 Microsoft Corporation, 2001-2005 Cambridge University Engineering Department.

-- ANNEX 1 --
Speakers directories

French speakers:
(31 speakers / 3100 utterances)

FABF	FAJF	FCCF	FDLM	FFLM	FJHM	FJRM	FMGF	FOMF	FSVF
FACF	FBGF	FCLF	FECF	FHSM	FJLM	FJVM	FMHF	FSHM	FTEM
FACM	FCAM	FDFM	FEDM	FJFM	FJPM	FLCF	FMKF	FSPM	FVCM
			FFDM						

Greek speakers:
(20 speakers / 2000 utterances)

GAKF	GATM	GGEM	GGPM	GIEM	GNKM	GPMM	GSKF	GTAM	GVPM
GAPM	GFVF	GGFM	GHPF	GMKF	GNSF	GPVM	GSLM	GVAF	GVSF

Italian speakers:
(20 speakers / 2000 utterances)

IABM	IANF	ICDM	IFAF	IFMM	ILDF	IMSF	IPCM	IRGM	IVFF
IADM	ICBF	IDFM	IFLM	ILCM	IMPF	INMF	IPSM	IRPF	IVSF

Spanish speakers:
(10 speakers / 999 utterances)

SARM	SATM	SBRF	SCBF	SCRF	SFTM	SJCM	SJJM	SLGF	SMCM

-- ANNEX 2 --
List of sentences

A total of 331 different prompts compose the database. This is the list with their numbers.

Activate	138, 149, 216, 364, 367, 479, 511, 560, 626, 674, 854, 863
Add	54, 76, 496, 500, 523, 551, 629, 744, 747, 864, 867, 898, 964
Airport Map	14, 17, 59, 74, 77, 80, 101, 106, 238, 564, 703, 739, 904
Airport Nav	86, 128, 354, 357, 630, 688
AOC	88, 134, 135, 137, 181, 303, 359, 384, 515, 680, 728, 946
Approach	79, 90, 133, 171, 185, 226, 348, 406, 419, 494, 497, 714, 783
Arc	445, 541
Arc Mode	18, 49, 376, 430, 474, 477, 694, 803, 889, 945
Assigned level	91, 374, 377, 771
Assigned level eight eight nine	398
Assigned level Minus nine	733
Assigned level nine two three	859
Assigned level one three six five three	988
Assigned level Plus four	464
Assigned level six zero	916
Assigned level six zero six	215
Assigned level three four two	410
Assigned level three two four	46
Can accept	94, 97, 165, 293, 450, 478, 686, 718, 830, 849, 925, 953
Cancel	911, 939
Cancel Emergency	234, 256, 298, 333, 490, 634, 637, 870, 874, 918, 996
Can not accept	268, 280, 441, 466, 489, 524, 654, 657, 794, 923, 928, 985
Change	334, 337, 448, 451, 505, 716
Change Frequency	393, 444, 750, 795, 869, 958
Climb to	301, 624, 627, 670, 909, 973
Close	144, 189, 214, 217, 385, 498, 609, 620, 745, 753, 896, 980
Constraints	29, 311, 325, 484, 487, 534, 549, 563, 690, 855, 924, 927, 956
Descent to	866, 875
Emergency	26
ETA alpha november india golf victor At two three Hours four three Minutes	343
ETA bravo nine quebec papa xray At zero two one six	329

ETA charlie papa mike At four three seven Minutes	824, 827
ETA charlie seven mike fox five At three Hours four one Minutes	324
ETA delta golf alpha kilo alpha At six three	369
ETA delta romeo tango whiskey zero At eight Hours three six	864
ETA echo romeo quebec echo nine At three seven Minutes	708
ETA echo romeo yankee At four two	30
ETA fox six hotel xray mike At one zero nine	349
ETA juliet echo india tango At six seven	336
ETA juliet sierra five papa quebec At five six	834
ETA lima four uniform zulu whiskey At seven four four	631
ETA mike sierra eight oscar five At five four four	920
ETA nine juliet charlie five romeo At zero one five six	124, 127
ETA november xray two india juliet At eight four seven Minutes	446
ETA one alpha oscar romeo yankee At five five four	84, 87
ETA one india nine alpha yankee At three nine Minutes	681
ETA one kilo mike zero juliet At eight five three Minutes	164
ETA papa lima xray november sierra At three eight Minutes	575
ETA papa one juliet quebec three At three zero Minutes	904, 907
ETA romeo papa four seven xray At one seven two five Minutes	44
ETA seven papa two india tango At zero six eight Minutes	240
ETA seven zulu kilo juliet xray At zero Hours five eight	140
ETA sierra delta fox three six At zero six six Minutes	761
ETA sierra three bravo zulu alpha At zero five zero Minutes	860
ETA uniform xray three tango three At five Hours seven	44, 47
ETA victor xray lima delta november At zero zero Hours four nine Minutes	854, 857
ETA victor zulu one five foxtrot At five seven Minutes	754

ETA zero foxtrot mike papa seven At nine nine Minutes	203
ETA zero victor five nine whiskey At six nine	983
ETA zulu echo uniform tango alpha At eight one nine Minutes	611
ETA zulu india zulu alpha sierra At two six zero Minutes	538
ETA zulu one golf foxtrot romeo At two three Hours four one Minutes	698
FD Disengage	166, 168, 270, 279, 431, 494, 604, 607, 743, 769, 816, 841, 954
FD Engage	178, 180, 246, 271, 536, 594, 594, 597, 633, 791, 924, 968, 989
FD Off	741
FD On	290, 661
FMS	145, 191, 229, 278, 394, 673, 724, 727, 740, 776, 815, 829
Free text	69, 115, 174, 184, 187, 218, 341, 360, 735, 809, 903, 966
HF1	161, 260
HF1 one one zero three six	868
HF1 seven two seven zero	874, 877
HF1 six three eight five	636
HF1 six three six one	96
HF1 three zero seven eight	263
HF2 five eight seven four	314, 317
HF2 nine zero three six	61
HF2 six five zero nine	639
HF2 three six seven six	525
HF2 two one five zero three	510
Historic	19, 45, 103, 194, 197, 273, 294, 331, 358, 366, 770, 979, 995
ILS	129, 173, 759, 800
ILS Off	556, 585, 843, 930
ILS On	355, 378, 384, 387, 543, 890
Last	154, 228, 231, 265, 550, 605, 614, 617, 663, 676, 748, 929
Level	763
Level one eight nine zero two	981
Level one two five six three	21
Level one zero nine nine five	174, 177
List	56, 169, 328, 455, 561, 574, 574, 577, 583, 606, 610, 691
Maintaining	43, 361
Maintaining eight two five	176
Maintaining five eight six	364
Maintaining five nine seven	85
Maintaining Minus four four	934, 937
Maintaining one five eight five six	139
Maintaining seven five six	811

Maintaining seven four eight	746
Maintaining two eight zero	534, 537
Maintaining zero three five one five	210
Maintaining zero zero six one nine	623
Mayday Mayday	68, 199, 225, 414, 417, 423, 439, 634, 720, 805, 826, 850, 961
Message	9, 53, 84, 196, 285, 338, 391, 464, 467, 513, 530, 696, 779
Metar	108, 136, 255, 289, 316, 351, 493, 614, 684, 687, 710, 819
Modify	153, 201, 204, 245, 288, 476, 514, 517, 729, 773, 785, 790, 821, 948
Nav	155, 449, 481, 484, 503, 546, 861
ND	15, 151, 249, 258, 514, 570, 643, 645, 714, 717, 831, 876, 899
Next	83, 125, 274, 277, 371, 433, 704, 719, 725, 730, 806, 844, 847, 878, 951
OK	205, 540, 564, 567, 571, 724, 749, 804, 807, 828, 865, 873, 986
Pan Pan	221, 253, 300, 405, 488, 506, 554, 635, 648, 674, 677, 789
PFD	41, 143, 274, 309, 444, 447, 459, 495, 533, 700, 936, 955, 964, 967
Position bravo zulu whiskey lima one	233
Position charlie eight yankee tango yankee	213
Position delta mike papa alpha four	200
Position echo echo five echo three	900
Position eight lima tango lima fox	64, 67
Position foxtrot one fox oscar lima	598
Position foxtrot whiskey two seven zero	110
Position hotel fox kilo whiskey quebec	0
Position hotel quebec golf mike golf	963
Position hotel victor fox three charlie	74
Position india bravo foxtrot fox uniform	655
Position juliet golf november foxtrot november	120
Position juliet mike bravo india xray	721
Position juliet oscar romeo delta zulu	711
Position kilo four whiskey hotel seven	834, 837
Position kilo zulu xray golf november	11
Position nine four victor six oscar	60
Position one alpha november one charlie	814, 817
Position one bravo kilo golf four	104, 107
Position one uniform foxtrot charlie seven	34
Position one zulu eight quebec fox	204, 207
Position papa three echo yankee papa	319
Position quebec golf nine uniform hotel	701
Position quebec zulu kilo bravo november	974
Position romeo lima hotel delta mike	774

Position seven five yankee victor delta	784, 787
Position seven nine quebec india zero	31
Position sierra two kilo papa one	114
Position tango quebec papa golf fox	130
Position tango victor hotel golf zulu	943
Position three fox kilo four	578
Position two uniform sierra charlie seven	330
Position uniform echo mike victor oscar	548
Position victor nine sierra fox romeo	306
Position yankee three two yankee november	588
Position zulu three mike tango india	54, 57
Preferred level eight four nine	788
Preferred level five four three	163
Preferred level five one five	304
Preferred level five two zero	593
Preferred level four one eight	669
Preferred level Minus seven	416
Preferred level nine five three	186
Preferred level nine zero two	188
Preferred level seven nine two	100
Preferred level six one eight	335
Preferred level six zero nine	531
Preferred level zero six	584, 587
Previous	126, 239, 248, 283, 291, 314, 365, 389, 554, 557, 600, 871, 976
Print	23, 234, 237, 275, 296, 440, 501, 518, 619, 664, 775, 913, 938
Range eighty	4, 7, 123, 164, 167, 198, 334, 519, 568, 590, 641, 723, 764, 895, 940
Range forty	113, 158, 179, 305, 380, 381, 504, 653, 675, 764, 767, 836, 839
Range one hundred sixty	66, 118, 190, 195, 211, 284, 287, 413, 454, 758, 799, 856
Range three hundred twenty	14, 81, 344, 347, 443, 456, 818, 825, 931
Range twenty	320, 375, 539, 994, 997
Report	259, 318, 411, 435, 529, 544, 580, 685, 713, 754, 757, 846, 971
Request Climb to eight four five Due to weather	573
Request Climb to one one Due to performance	646
Request Climb to Plus three	148
Request Climb to seven nine Due to weather	858
Request Climb to six Due to weather	915
Request Climb to three seven Due to performance	345
Request Descent to five five two	603

Request Descent to four zero one Due to weather	121
Request Descent to Minus two Due to performance	230
Request Descent to Plus seven five Due to weather	124
Request Descent to Plus seven five six Due to aircraft performance	304, 307
Request Descent to six Due to weather	25
Request Descent to six eight five Due to performance	38
Request Descent to six four five Due to performance	901
Request Descent to zero two Due to aircraft performance	738
Request Descent to zero zero seven six five Due to weather	709
Request Direct to charlie four romeo hotel echo Due to weather	71
Request Direct to charlie india whiskey Due to weather	276
Request Direct to delta sierra india nine hotel Due to weather	934
Request Direct to echo uniform six delta uniform Due to aircraft performance	184
Request Direct to foxtrot one sierra quebec november Due to performance	545
Request Direct to juliet eight	535
Request Direct to lima foxtrot uniform bravo nine Due to aircraft performance	820
Request Direct to lima tango oscar six zulu	193
Request Direct to mike victor seven delta delta Due to performance	880
Request Direct to nine whiskey romeo Due to performance	615
Request Direct to one charlie sierra two five Due to weather	70
Request Direct to one tango six oscar india Due to weather	555
Request Direct to oscar four victor alpha zero Due to aircraft performance	183
Request Direct to oscar lima alpha golf romeo Due to weather	346
Request Direct to romeo xray delta four zero Due to performance	558
Request Direct to sierra foxtrot uniform tango juliet Due to weather	409
Request Direct to sierra two charlie fox romeo Due to performance	379

Request Direct to six oscar india whiskey november Due to weather	286
Request Direct to tango bravo alpha papa xray Due to performance	944
Request Direct to uniform kilo bravo two oscar Due to weather	4
Request Direct to victor lima bravo romeo Due to aircraft performance	170
Request Direct to victor nine delta foxtrot golf Due to weather	326
Request Direct to whiskey november bravo hotel yankee Due to weather	426
Request Direct to whiskey oscar echo foxtrot delta Due to weather	794, 797
Request Direct to yankee Due to weather	840
Request Direct to yankee echo hotel Due to weather	223
Request Direct to zero Due to aircraft performance	621
Request Level four Due to weather	396
Request Level four zero five Due to weather	914, 917
Request Level Minus six Due to performance	628
Request Level Minus three zero	400
Request Level Plus zero three Due to aircraft performance	658
Request Level seven three two Due to aircraft performance	295
Request Level six Due to performance	36
Request Level six zero three Due to performance	414
Request Speed four Dot zero	111
Request Speed four Point zero Due to aircraft performance	323
Request Speed four Point zero Due to performance	824
Request Speed four Point zero Due to weather	755
Request Speed Minus six Due to weather	429
Request Speed three Point six nine Due to performance	399
Request Speed two Dot seven four	651
Request Speed two Point one four	801
Request Speed zero Decimal nine seven Due to performance	960
Request Speed zero Dot nine one Due to performance	363

Request Speed zero Dot six six nine Due to performance	339
Request Speed zero Point five seven six Due to aircraft performance	114, 117
Request Speed zero Point seven Due to performance	668
Roger	89, 383, 486, 581, 589, 644, 650, 694, 695, 697, 844, 944, 947
Rose	75, 284, 468, 704, 707, 808, 883, 891
Rose Mode	13, 281, 595, 736, 760, 879
Route	6, 63, 224, 310, 394, 397, 471, 485, 508, 608, 613, 656
Select HF1 five zero nine two	425
Select HF1 three six nine six	374
Select HF1 two eight three zero	559
Select HF1 two two zero zero zero	434, 437
Select HF2 nine zero one two	175
Select HF2 nine zero seven two	991
Select HF2 seven zero seven six	586
Select HF2 three four nine six	793
Select HF2 three six five eight	404
Select HF2 two eight three two	388
Select HF2 two zero seven eight five	618
Select VHF1	141
Select VHF2	706, 731
Select VHF2 one eight seven	150, 734, 737, 908
Select VHF2 one five two Decimal zero	473
Select VHF2 one six five	970
Select VHF2 one six nine Decimal nine four	835
Select VHF2 one two nine Decimal three	569
Select VHF2 one zero three Decimal nine six	744
Select VHF3	65, 528, 599
Select VHF3 one eight nine	950
Select VHF3 one eight nine Decimal nine nine	28
Send	3, 51, 134, 254, 257, 269, 408, 453, 475, 509, 596, 640, 905
SID	241, 424, 427, 458, 520, 604, 666, 678, 715, 833, 884
Speed four Decimal zero	881, 993
Speed four Dot zero	104, 386, 798
Speed four Point zero	526, 990
Speed Minus two six	765
Speed Minus zero two	24, 27
Speed one Decimal seven zero six	144, 147
Speed one Dot three three eight	20
Speed one Point one seven one	64
Speed two Dot one three	8

Speed zero Decimal nine two four	40
Speed zero Dot eight zero one	984
Standby	58, 119, 264, 264, 267, 321, 553, 786, 810, 894, 921, 975, 999
Switch	315, 404, 407, 480, 625
Switch Frequency	94, 109, 208, 243, 401, 689, 726
TAF	95, 308, 470, 474, 521, 644, 647, 649, 848, 853, 885, 906
Time eight eight	766
Time five nine Minutes	244, 247
Time four eight	969
Time nine Hours two one Minutes	250
Time nine two four	214
Time seven one zero	395
Time six Hours eight Minutes	491
Time three seven Minutes	683
Time zero eight nine Minutes	418
Time zero five six Minutes	159
Time zero four eight Minutes	266
Transfer	206, 220, 235, 261, 299, 354, 368, 403, 616, 664, 667, 781, 949
Unable	499, 544, 547, 591, 638, 705, 734, 756, 780, 893, 941, 974, 977, 994
Undo	33, 156, 209, 415, 438, 460, 461, 524, 527, 576, 624, 933, 959
Vertical	39, 48, 55, 131, 236, 324, 327, 340, 353, 424, 579, 926
VHF1	5, 16, 254, 463, 768, 796
VHF1 one five zero Point seven zero	160
VHF1 one four three	751
VHF1 one one eight Dot three five	34, 37
VHF1 one one four Decimal five three	998
VHF1 one seven four Point seven eight	78
VHF2	884, 887
VHF2 one four five Decimal one three	434
VHF3	373, 420, 665
VHF3 one three six Dot nine five	965
VHF3 one two seven	194
VHF3 one two three	154, 157
VOR	1, 35, 116, 344, 454, 457, 659, 660, 823, 851, 886, 894, 897, 978
Weather Off	390, 565, 778, 914
Weather On	24
Weather Radar	350, 693, 910
Weather Radar Off	99, 244, 935
Weather Radar On	105, 294, 297, 436, 919, 984, 987
We can accept eight seven one At eight zero one Minutes	838
We can accept Minus six At zero six Minutes	313

We can accept Minus three five At three two two	671
We can accept nine six seven At three zero Minutes	784
We can accept one three nine one six At five Hours two three Minutes	954, 957
We can accept Plus five At zero Hours seven	814
We can accept Plus five At zero one seven Minutes	50
We can accept Plus five seven seven At seven six Minutes	774, 777
We can accept Plus three three At one five Hours nine	516
We can accept six At six nine	421
We can accept six zero At five eight Minutes	679
We can accept zero seven five four seven At eight two nine Minutes	684
We cannot accept eight eight nine	601
We cannot accept eight three nine	888
We cannot accept five	813
We cannot accept five one	845
We cannot accept Minus four eight	804
We cannot accept one seven eight six four	504, 507
We cannot accept one six six eight eight	428
We cannot accept Plus nine nine nine	73
We cannot accept Plus zero one five nine one	10
We cannot accept seven two four	699
We cannot accept six eight four	566
We cannot accept six four six	654
Wilco	93, 98, 146, 219, 224, 227, 251, 356, 370, 465, 469, 483, 584

-- ANNEX 3 --
Task grammar

This is the grammar describing the HIWIRE recognition task. The format is compatible with HParse.

```
$NON_ZERO_DIGIT =  one | two | three | four | five | six | seven | eight | nine ;
$DIGIT = one | two | three | four | five | six | seven | eight | nine | zero ;
$LETTER = alpha | bravo | charlie | delta | echo | foxtrot | golf | hotel | india | juliet |
          kilo | lima | mike | november | oscar | papa | quebec | romeo | sierra | tango |
          uniform | victor | whiskey | x-ray | yankee | zulu ;
$ALPHANUM = $LETTER | $DIGIT ;

$DIGIT1_4 = one | two | three | four | zero ;

$HF =
       (HF1 | HF2 )
       (
              ( two ( eight | nine ) $DIGIT $DIGIT ) |
              ( ( three | four | five | six | seven | eight | nine ) $DIGIT $DIGIT $DIGIT ) |
              ( $NON_ZERO_DIGIT $DIGIT $DIGIT $DIGIT ) |
              ( one  $DIGIT $DIGIT $DIGIT $DIGIT ) |
              ( two  ( zero | one)  $DIGIT $DIGIT $DIGIT ) |
              ( two  two  zero zero zero )
       )
       ;
$POINT = ( decimal | point | dot ) ;
$VHF = ( VHF1 | VHF2 | VHF3 ) [  one $DIGIT $DIGIT   [  $POINT $DIGIT [$DIGIT]  ]    ];
$PAN = pan pan ;

$MAYDAY = mayday mayday ;

$FOURDIGITS = $DIGIT [$DIGIT]  [$DIGIT]  [$DIGIT] ;
$FLOAT = $DIGIT1_4 ( $POINT ) $DIGIT [$DIGIT]  [$DIGIT] ;

$ADDIT = due to ( weather | performance | aircraft performance ) ;

$TIME = [
              $DIGIT [$DIGIT] [hours]
       ]

       (
              $DIGIT $DIGIT
              [minutes]
       )
       ;

$SPEED =
       (
              [ plus ]
              (
                     ( four zero zero zero ) |
                     (
                            ( three | two | one ) $DIGIT $DIGIT $DIGIT
                     ) |
                     ( [ zero ] $DIGIT $DIGIT $DIGIT ) |
                     ( [ zero ] [ zero ] $DIGIT $DIGIT ) |
                     ( [ zero ] [ zero ] [ zero ] $DIGIT )
              )
       )
       |
       (
              minus
              (
                     ( one zero zero ) |
                     ( [ zero ] $DIGIT $DIGIT )
              )
       )
       |
       (
              ( zero $POINT ( five | six | seven | eight | nine ) [ $DIGIT ] [ $DIGIT ] [ $DIGIT ]
) |
              ( ( one | two | three ) $POINT $DIGIT [ $DIGIT ] [ $DIGIT ] [ $DIGIT ] ) |
```

```
                ( four $POINT zero [zero] [zero] [zero] )
        ) ;


$POSITION = $ALPHANUM [$ALPHANUM] [$ALPHANUM] [$ALPHANUM] [$ALPHANUM] ;

$LEVEL =
        (
                [plus]
                (
                        ( ([zero] | one | two) $DIGIT $DIGIT $DIGIT $DIGIT ) |
                        ( $DIGIT [$DIGIT] [$DIGIT] )
                )
        ) |
        (
                minus
                (
                        ( six zero ) |
                        ( ( five | four | three | two | one | [zero] ) $DIGIT )
                )
        ) ;

$REQUEST = request | request speed $SPEED [$ADDIT] | request direct to $POSITION [$ADDIT] |
           request level $LEVEL [$ADDIT] | request descent to $LEVEL [$ADDIT] |
           request climb to $LEVEL [$ADDIT] ;

$ETA = ETA $POSITION at $TIME;
$ON_OFF =  on | off ;
$WEATHER = weather [radar] [$ON_OFF];
$RANGE = twenty | forty | eighty | one hundred sixty | three hundred twenty ;
$MAP_NAV = map | nav ;
$AIRPORT = airport [$MAP_NAV] ;
$SELECT = select ( $VHF | $HF );
$START = start;
$END = end;

$COMMAND = AOC | $REQUEST | report | emergency | message | historic | add |
           cancel [emergency] |
           close | last |
           list | modify | metar | next | previous | print | send | TAF | ok | undo |
           wilco | unable | standby | roger | can accept | cannot accept |
           vertical | route | speed | level | climb to | descent to | direct to |
           maintaining [$LEVEL] |
           assigned level [$LEVEL] |
           $ETA |
           preferred level [$LEVEL] |
           $ADDIT |
           free text |
           level $LEVEL |
           speed $SPEED |
           position $POSITION |
           time $TIME |
           SID | VOR | PFD | FMS |
           nav | ND |
           $WEATHER |
           arc [mode] |
           rose [mode] |
           constraints |
           range $RANGE |
           $AIRPORT |
           approach |
           ILS [$ON_OFF] |
           FD [$ON_OFF] |
           FD engage |
           FD disengage |
           transfer | activate |
           change [frequency] |
           switch [frequency] |
           $SELECT | $VHF | $HF | $PAN | $MAYDAY |
           we can accept $LEVEL at $TIME |
           we cannot accept $LEVEL ;


( [$START] $COMMAND  [$END] )
```