INTEGRAT Demonstration and Instructions for Use

Reading the Mind of the AI Robot

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Why is INTEGRAT important?

- It used to be that only human experts examined data and made decisions. Now Artificial Intelligence (AI) is enabling robotic decision making in an ever-widening variety of applications. As society allows this to happen, there is a greater likelihood that these robot decisions can affect people's lives. It makes sense, therefore, to understand the capabilities and societal implications of AI robots.
- Big data is a term used to describe both the opportunities and the problems associated with so much information now available for decision making. With the advent of the Internet of Things (IoT) the impact of this huge amount of data is only growing. Actionable decisions need to be distilled from big data and AI can only go so far based on linear extrapolation. Because of this, many non-linear deep learning algorithms are being developed.

What exactly have these AI robots learned so deeply from all of this big data?

- This question is very reasonable for society to ask. It is not enough to train and create a great AI robot. Many researchers are realizing that before their systems can be deployed, they must be able to prove to human experts that the robots learned the right things from the right data. This is difficult because human expert decision makers are not necessarily the same people who are good at creating robot AI. These two teams must work together in a user friendly way.
- **If only we could read the robot mind.**

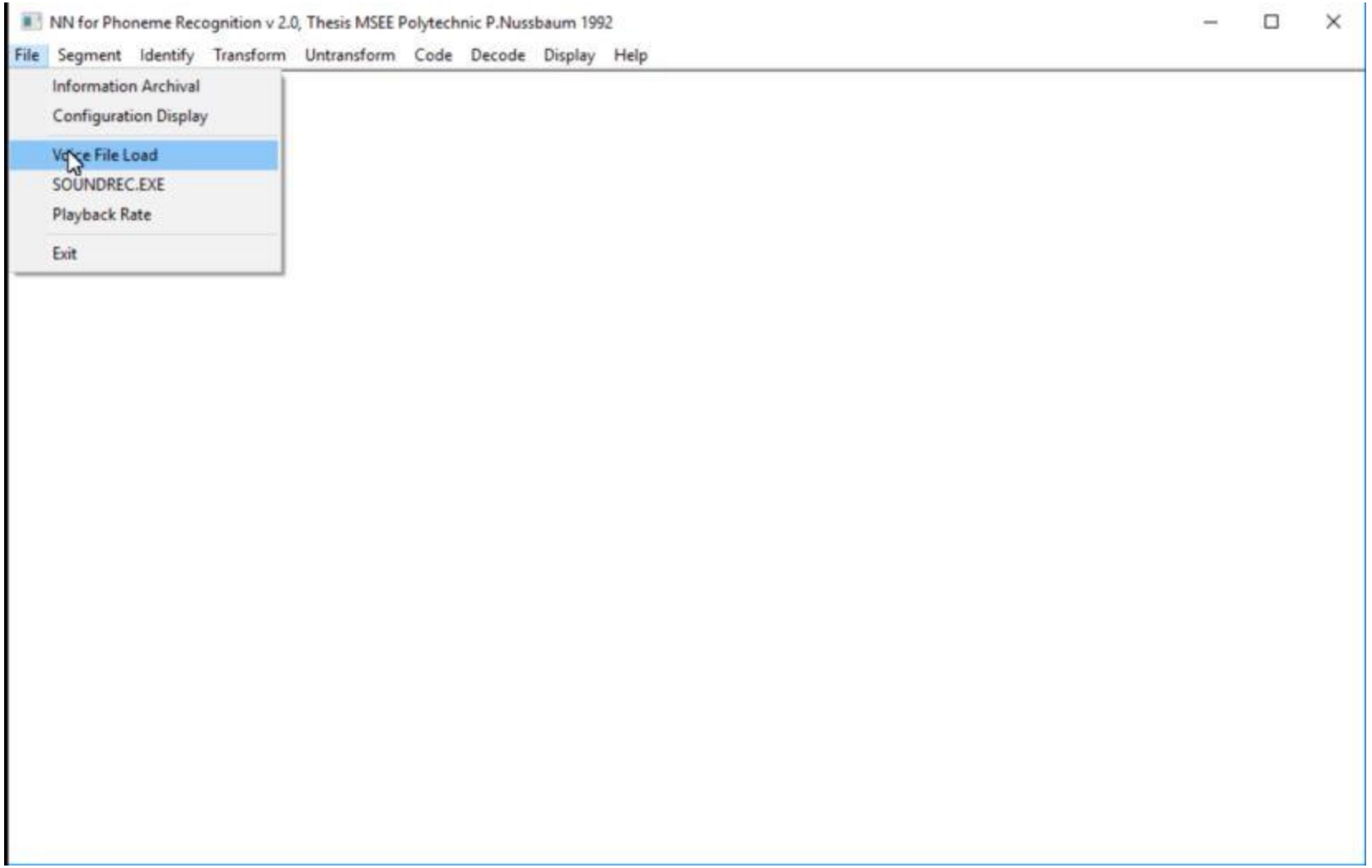
INTEGRAT was covered by 4 U.S. Patents. These have now expired…

- Recently some old research of mine has been getting increased attention by engineers and scientists working on exactly the issues discussed above. This research yielded four US patents and a Windows app that gives a friendly user interface to allow examination of big data and inner workings of a trained AI decision maker. I never publically released the software, called INTEGRAT, because I sold rights to the patents to my employer at the time. Now that the patents have expired, I can share my work, as well as the software specifically designed to read the mind of the robot.
- To make this research more easily accessible I am releasing the software for Windows, a short YouTube video explaining how to use the software, and the source code on GitHub.
- https://github.com/prof-nussbaum/INTEGRAT-reading-the-mind-of-the-AI-robot

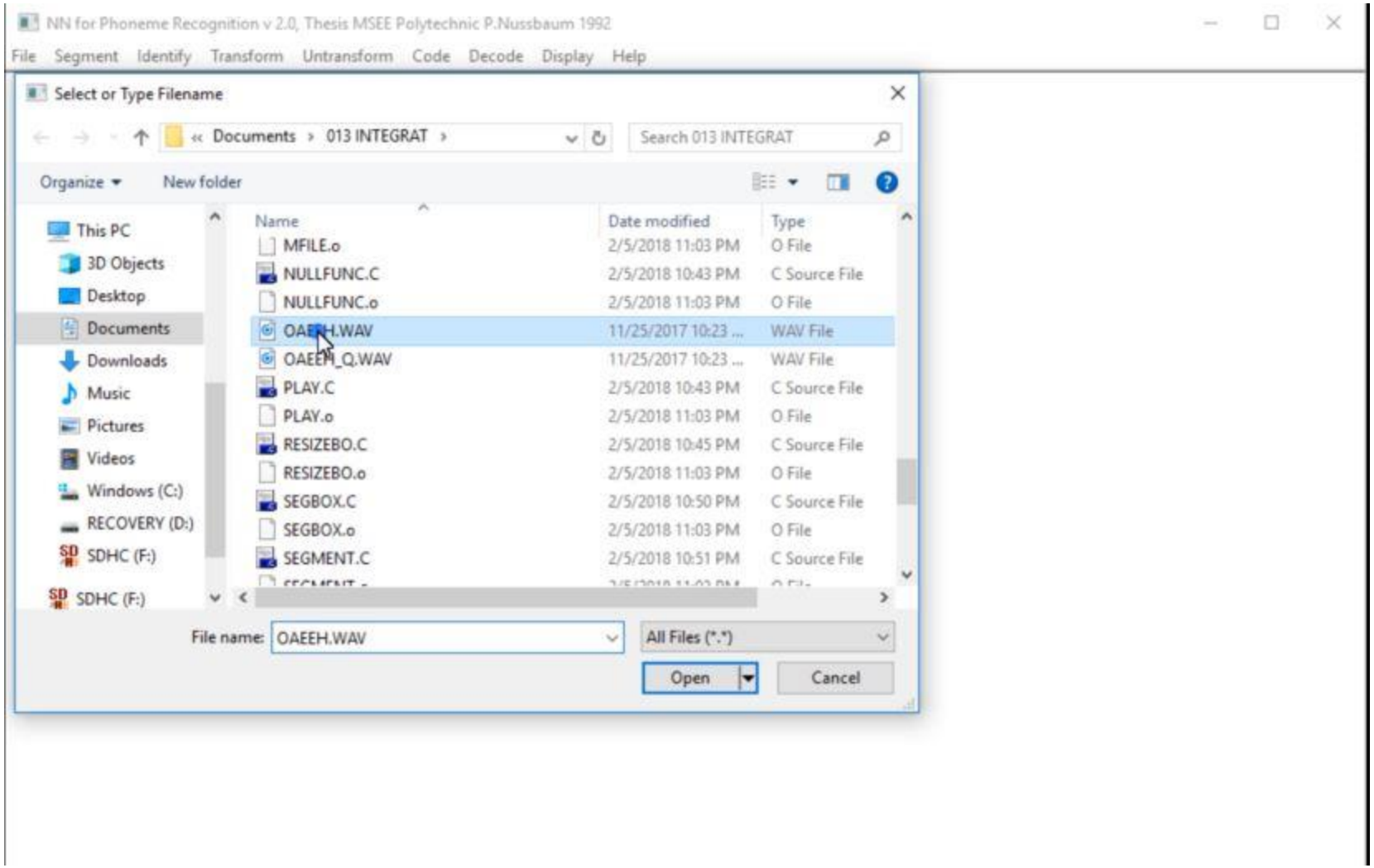
What does INTEGRAT do?

- If you can speak and understand human speech, then you are an expert phoneme recognizer. If you could not tell the difference between phonemes, you would not be able to understand human speech.
- For this reason, INTEGRAT focuses on phoneme recognition. Unlike biomedical signal analysis, stock market analysis, or any number of other AI applications, INTEGRAT lets the robot developer also act as the subject matter expert.
- INTEGRAT lets the user develop a complete AI robot to recognize phonemes.
- INTEGRAT also lets users “read the mind of the robot” and check that it learned the right things from the right data.

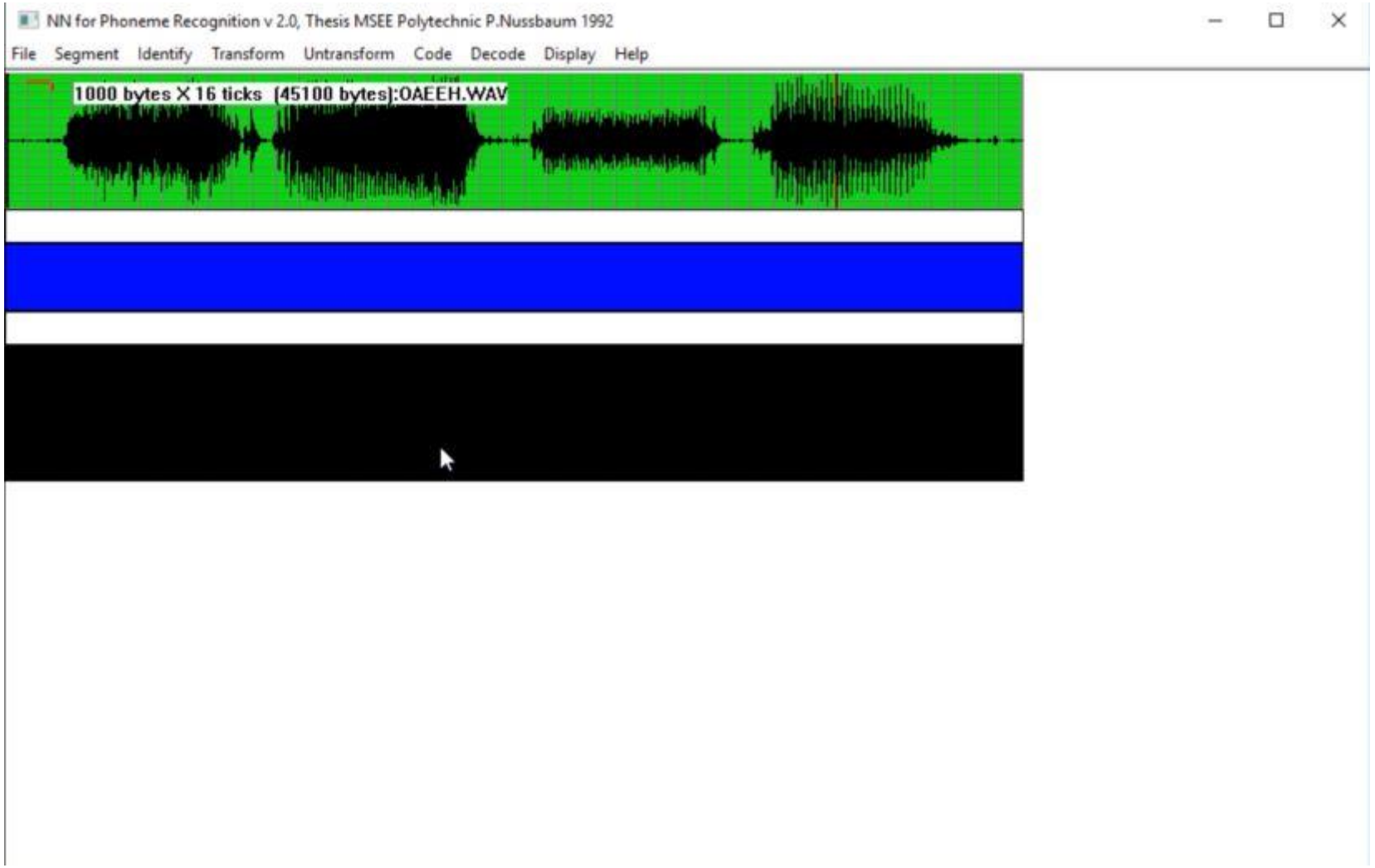
This is the opening screen of the INTEGRAT program running in the Windows 10 operating system.



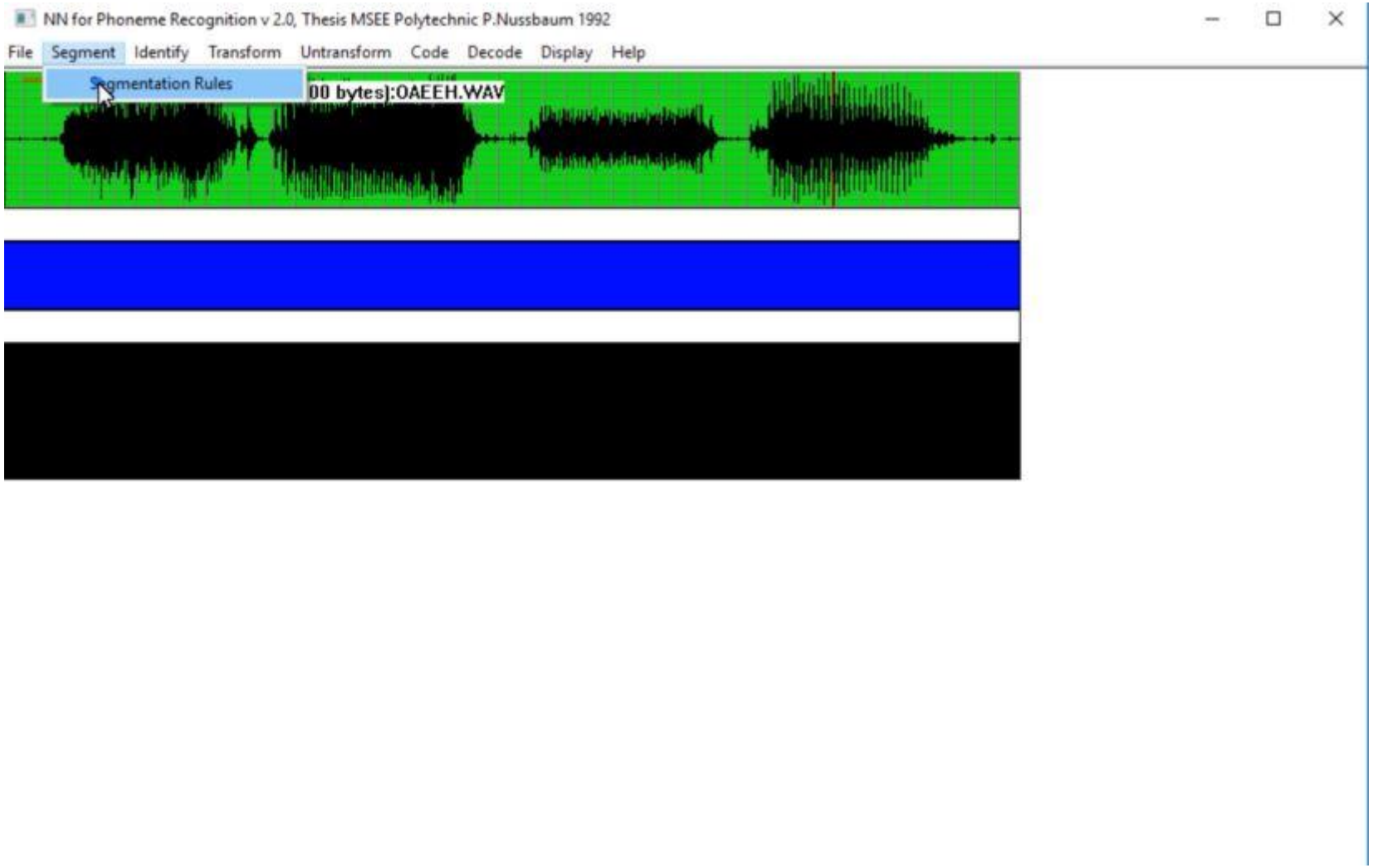
To begin, load an audio file containing phoneme examples. These will be used to train the AI robot.



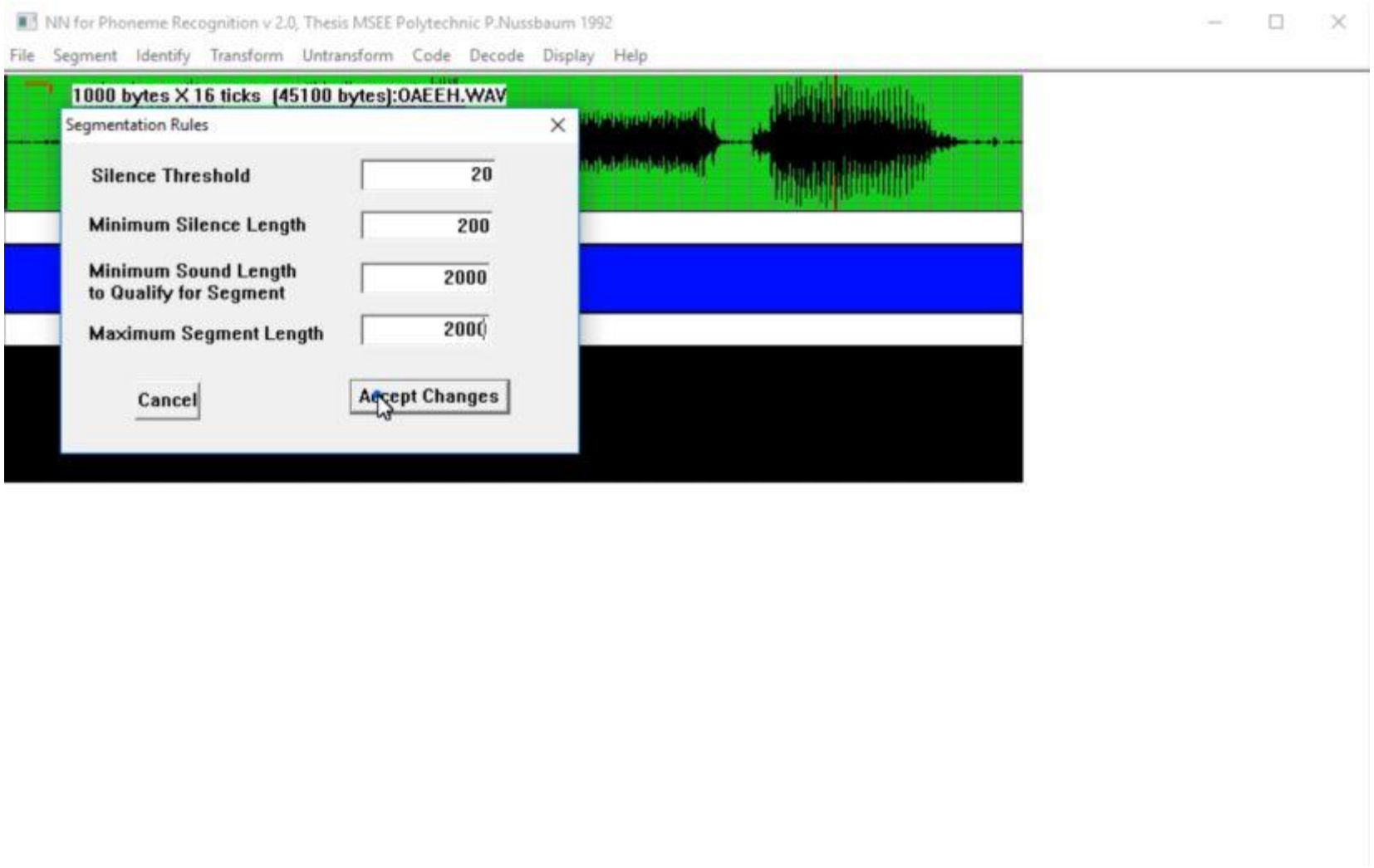
The sample file OAHEEH.wav is included with the INTEGRAT source code.



This audio file has a single person speaking aloud four simple vowel phonemes – OO, AH, EE, and EH

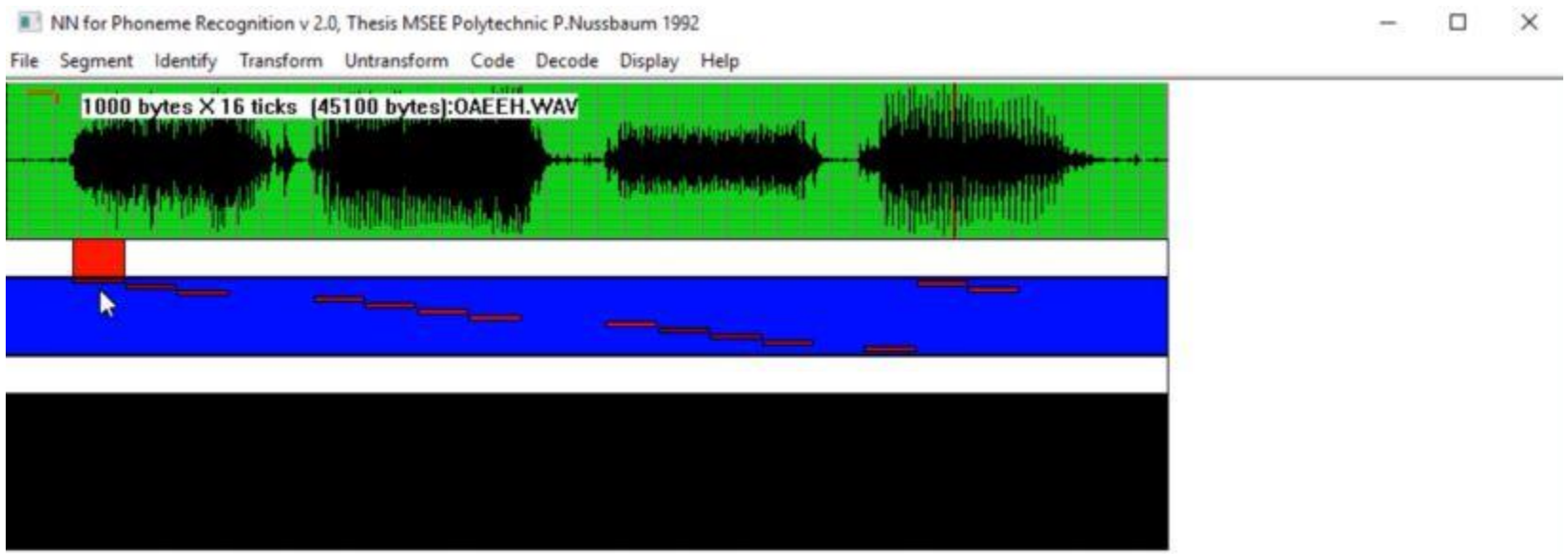


Before data can be used for training or testing, it must be divided into segments that can be individually identified.

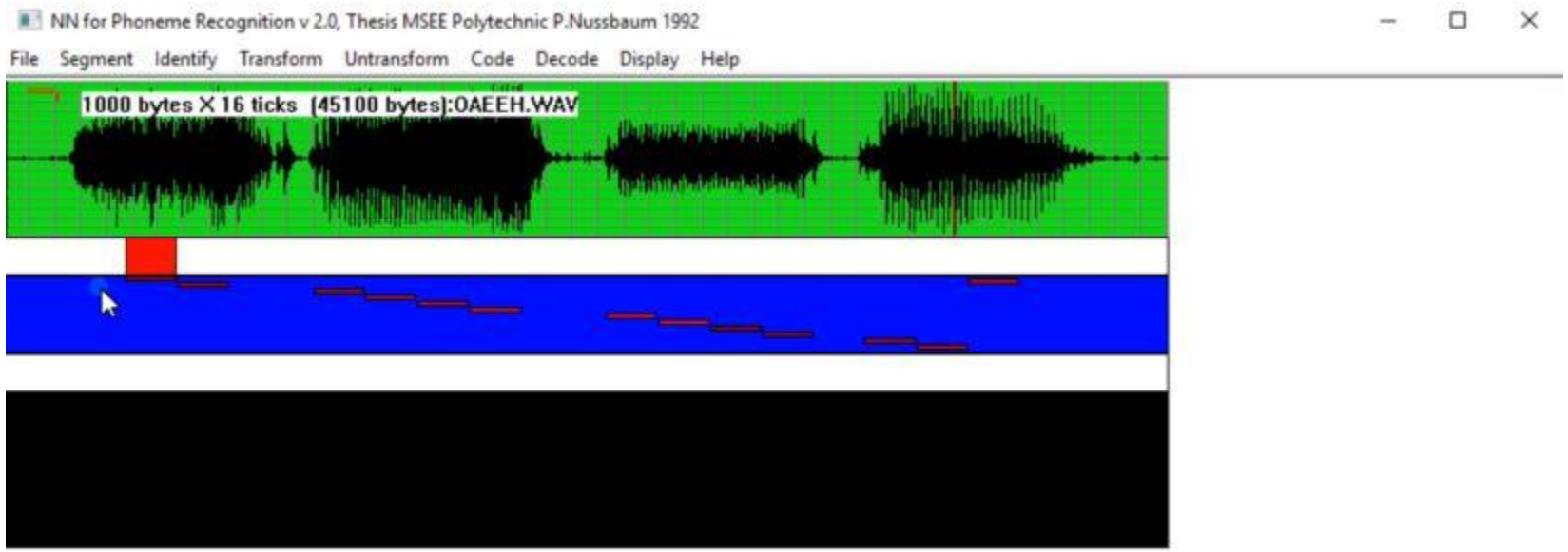


Here, automated segmentation parameters can be configured.
Segments can also be manually added by clicking in the green area

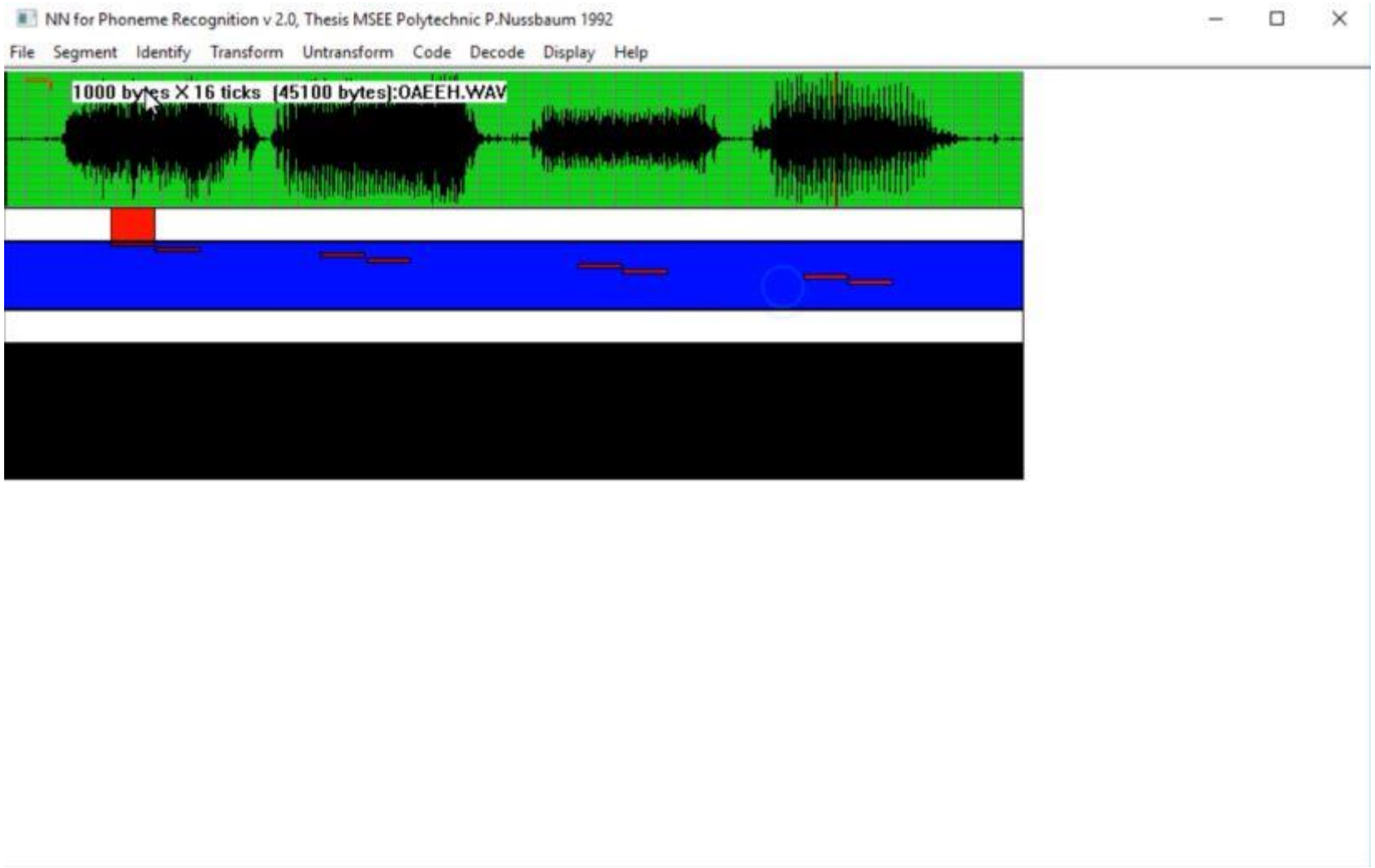
Once the segments have been created,



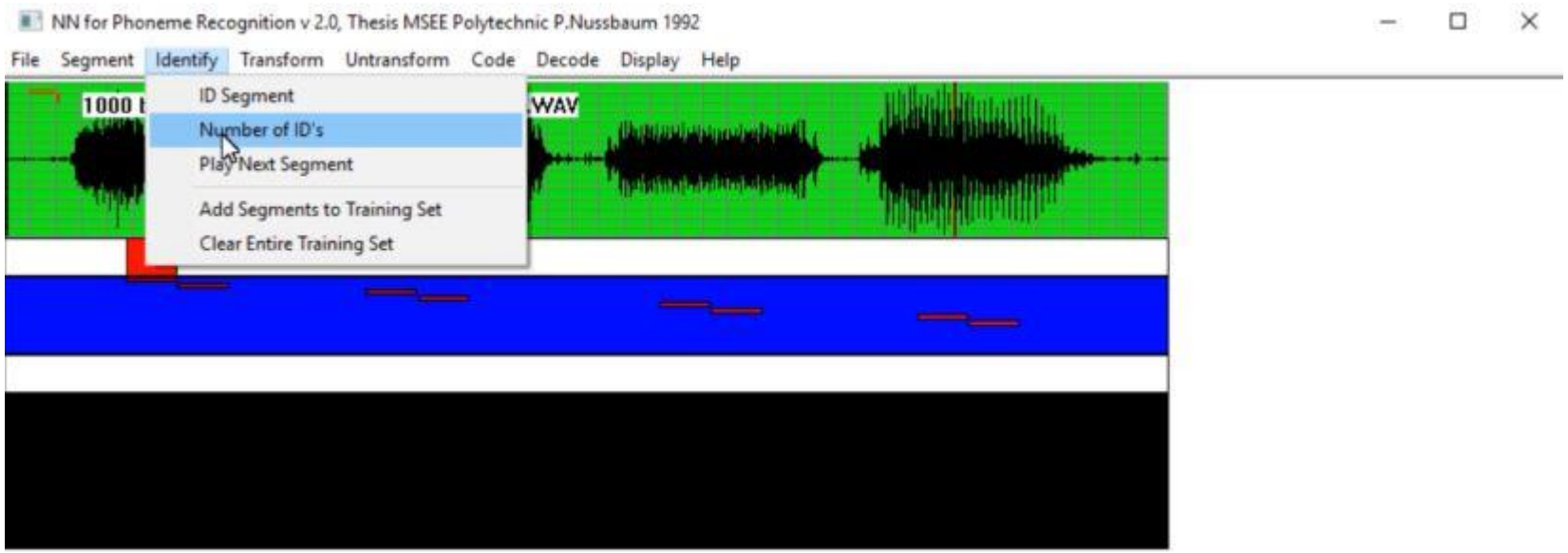
Since each segment must be identified by the human expert, the human expert can examine segments one by one. In this case, segments can be examined visually and audibly. Segments can be removed by clicking in the blue area.



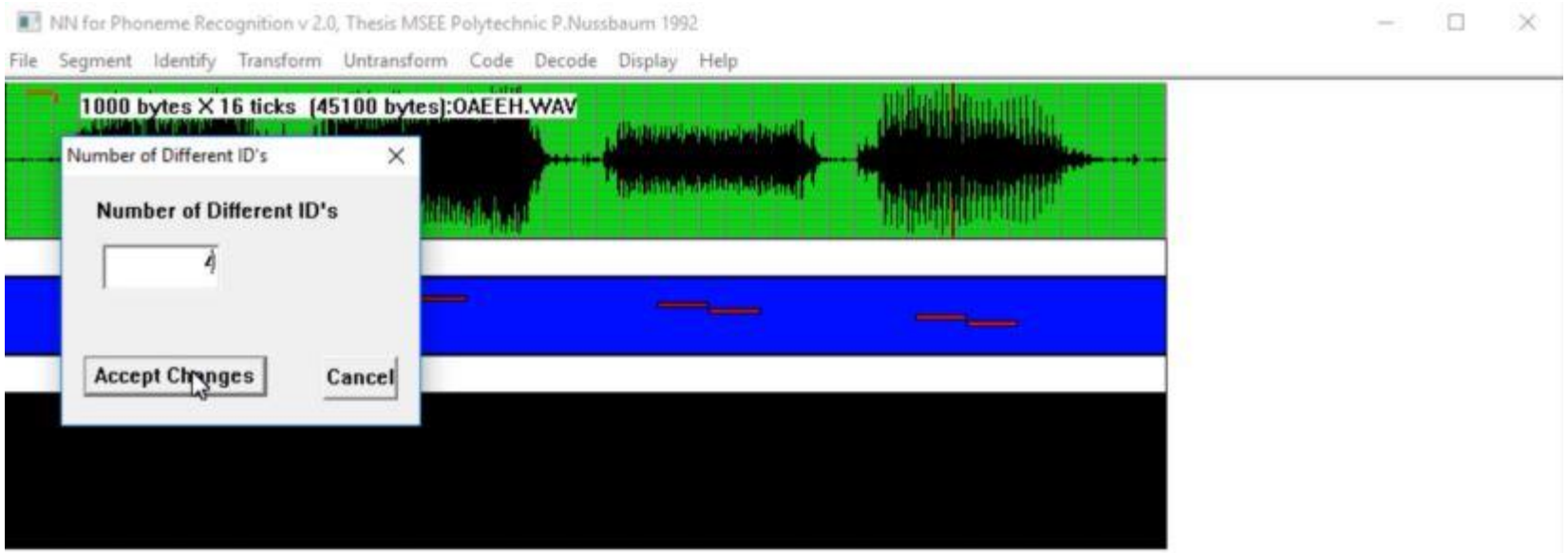
If a segment is deemed to be less than optimal, it can be omitted from the training data set.



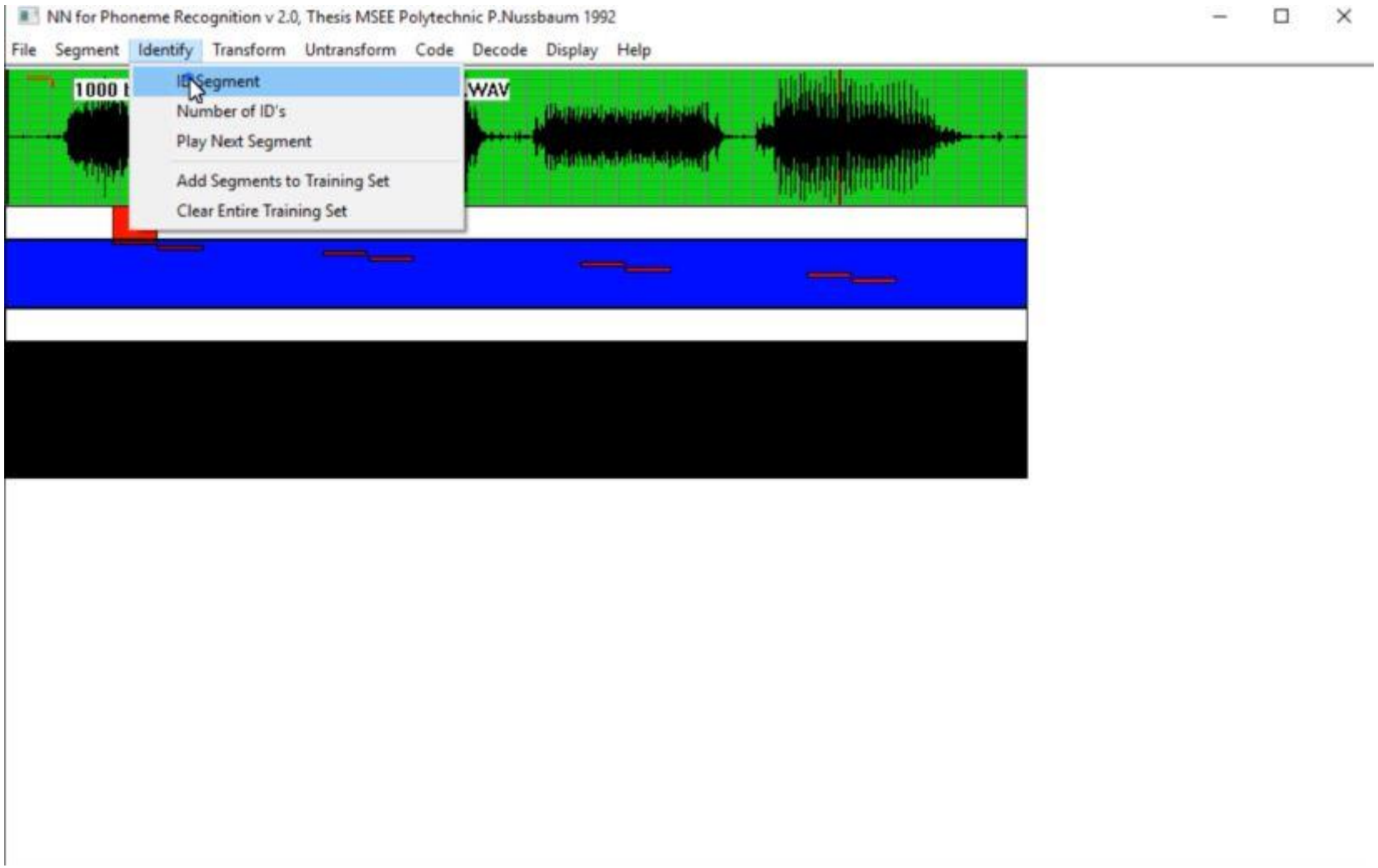
The human expert has deleted several segments. Only the best segments have been kept for the training set.



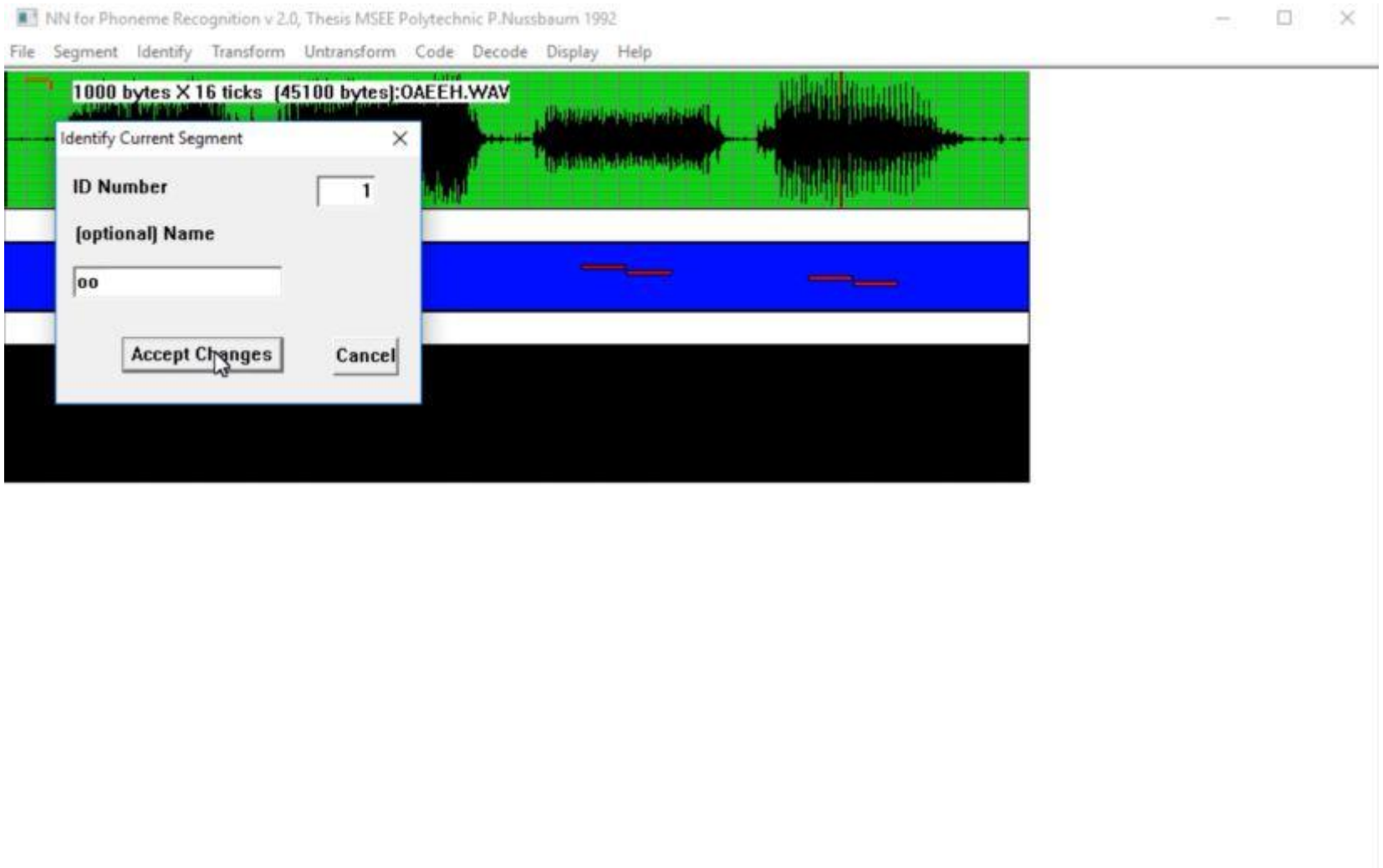
The human expert is now asked to make an estimate of the number of different phonemes the AI robot will encounter. This number of possible identifications will help to dimension the AI system.



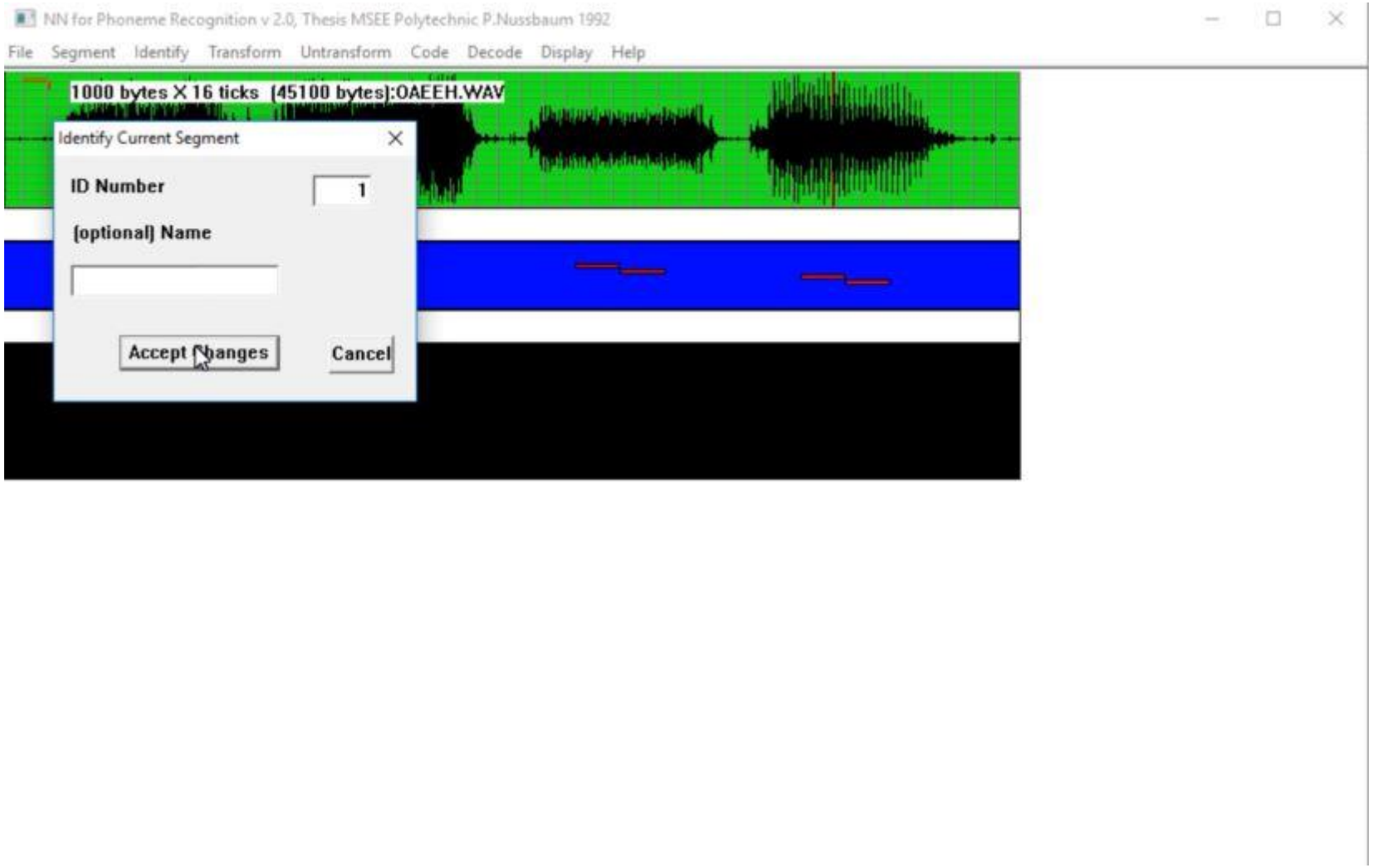
In this simple example, there are only 4 different phonemes.



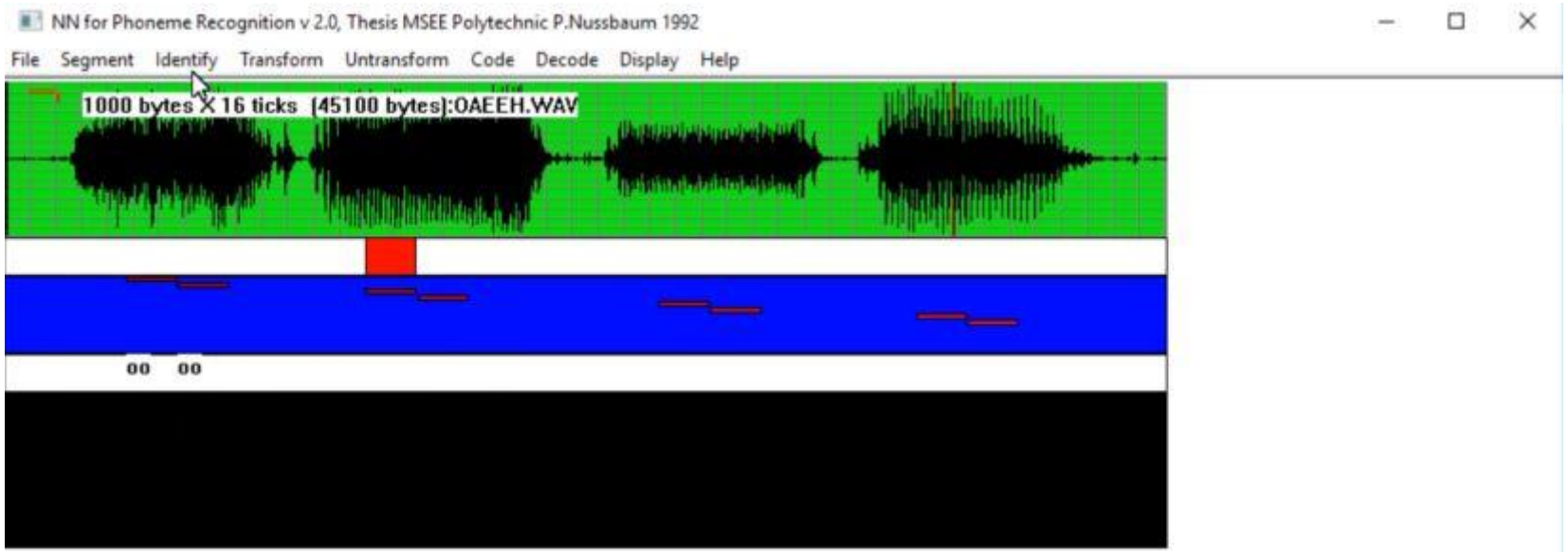
One by one, the human expert assigns each data segment to an identification number.



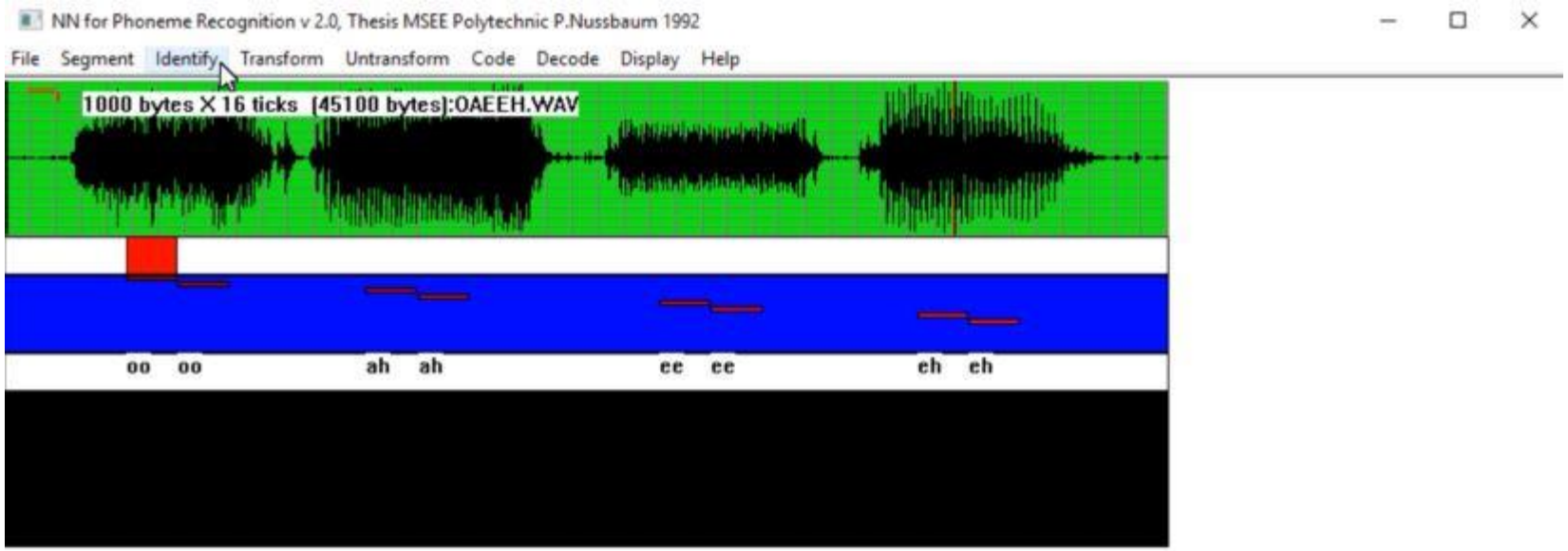
Each identification number can also optionally be assigned a short name.



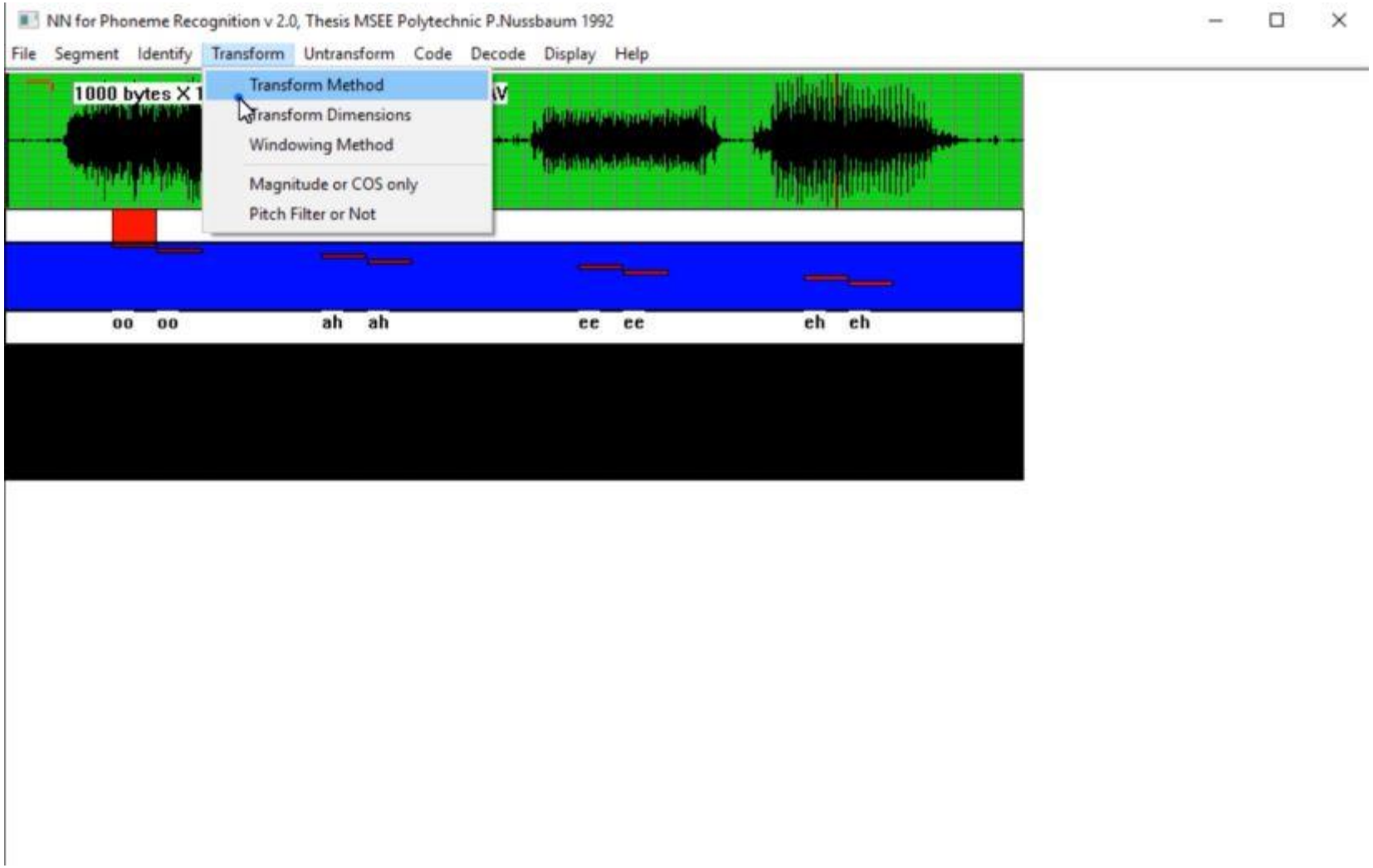
The short name does not need to be entered every time. The identification number is sufficient.



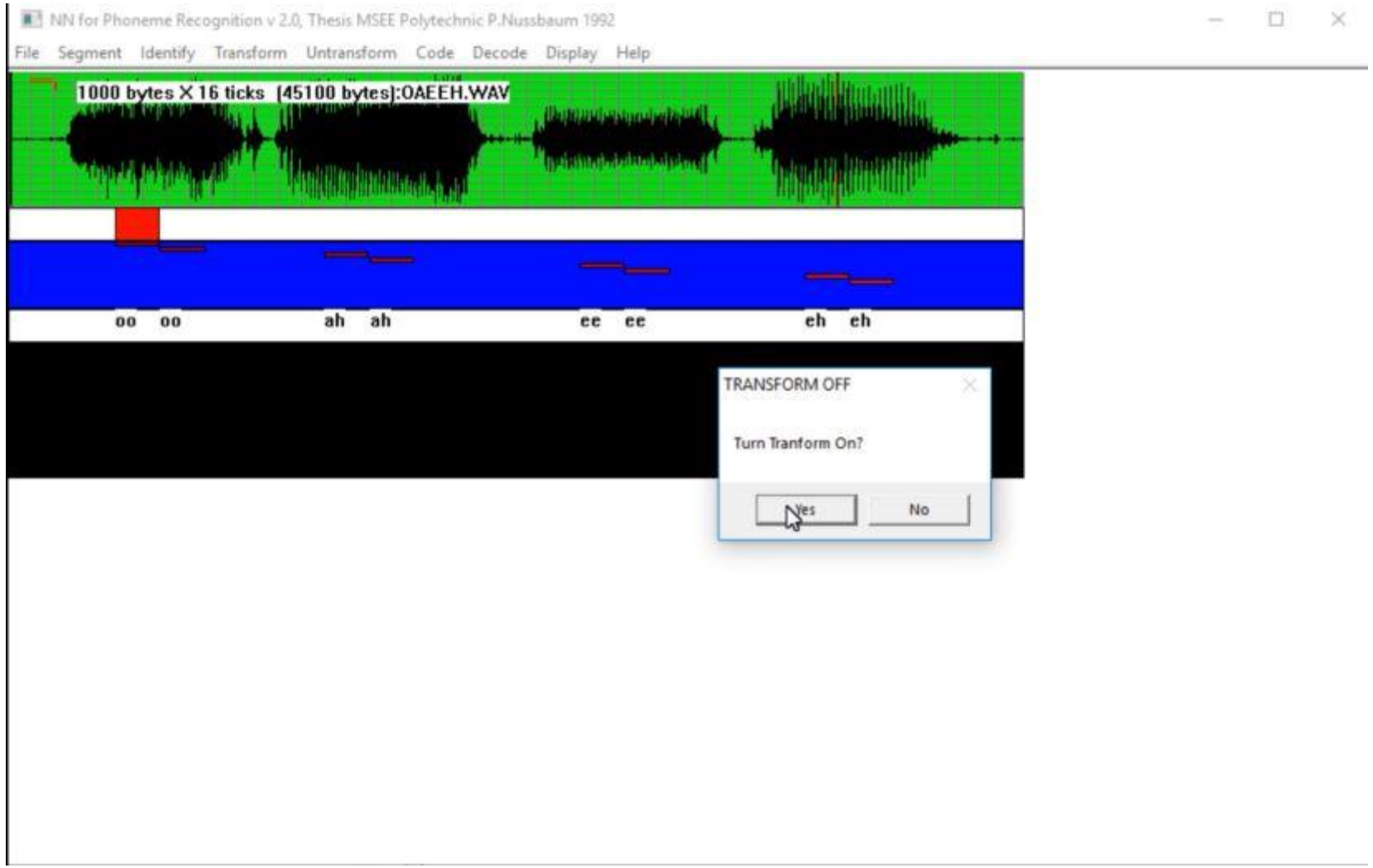
As the human expert identifies the segments, they can also inspect them (visually and audibly).



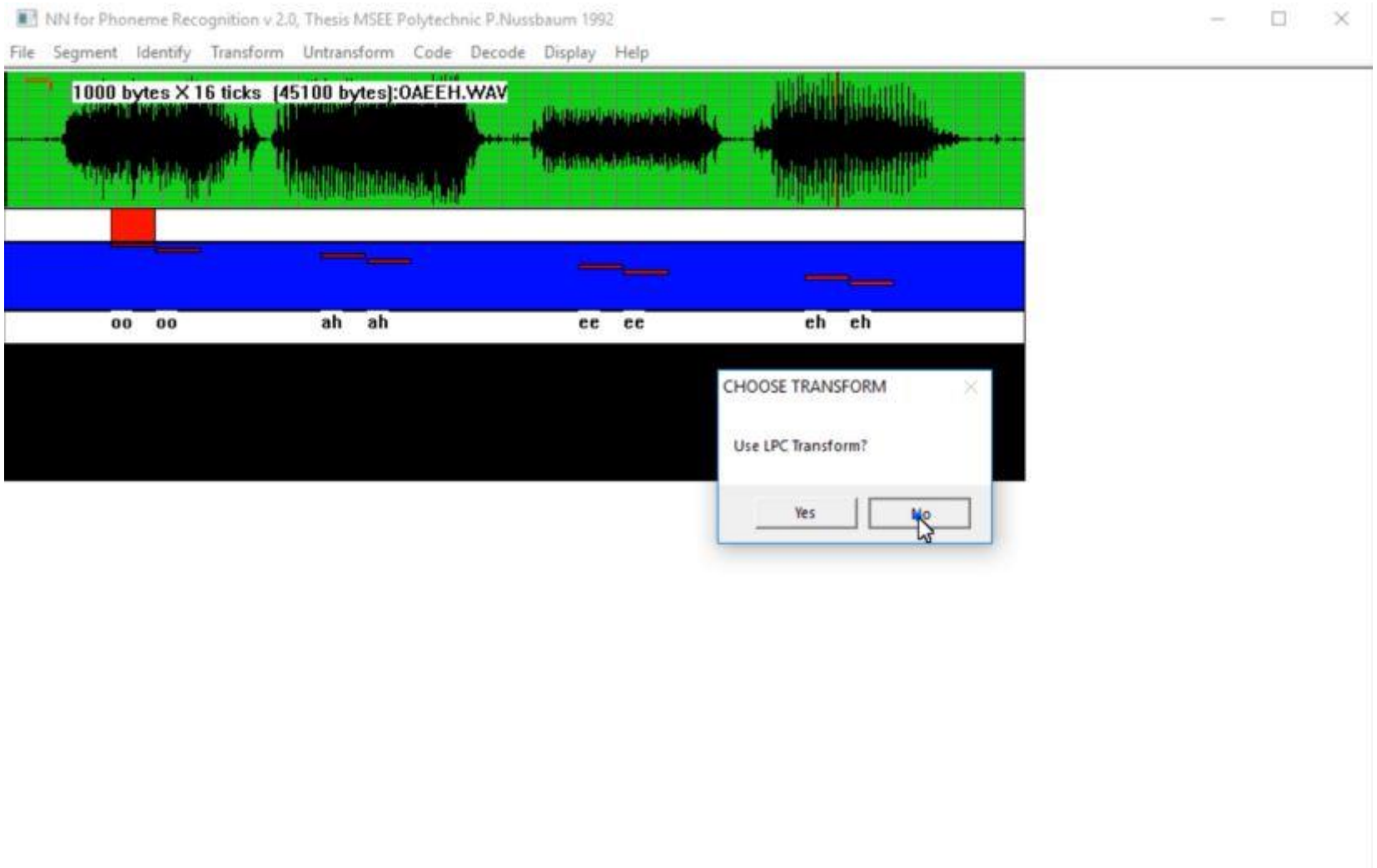
If a short name was provided, it appears under the segments.



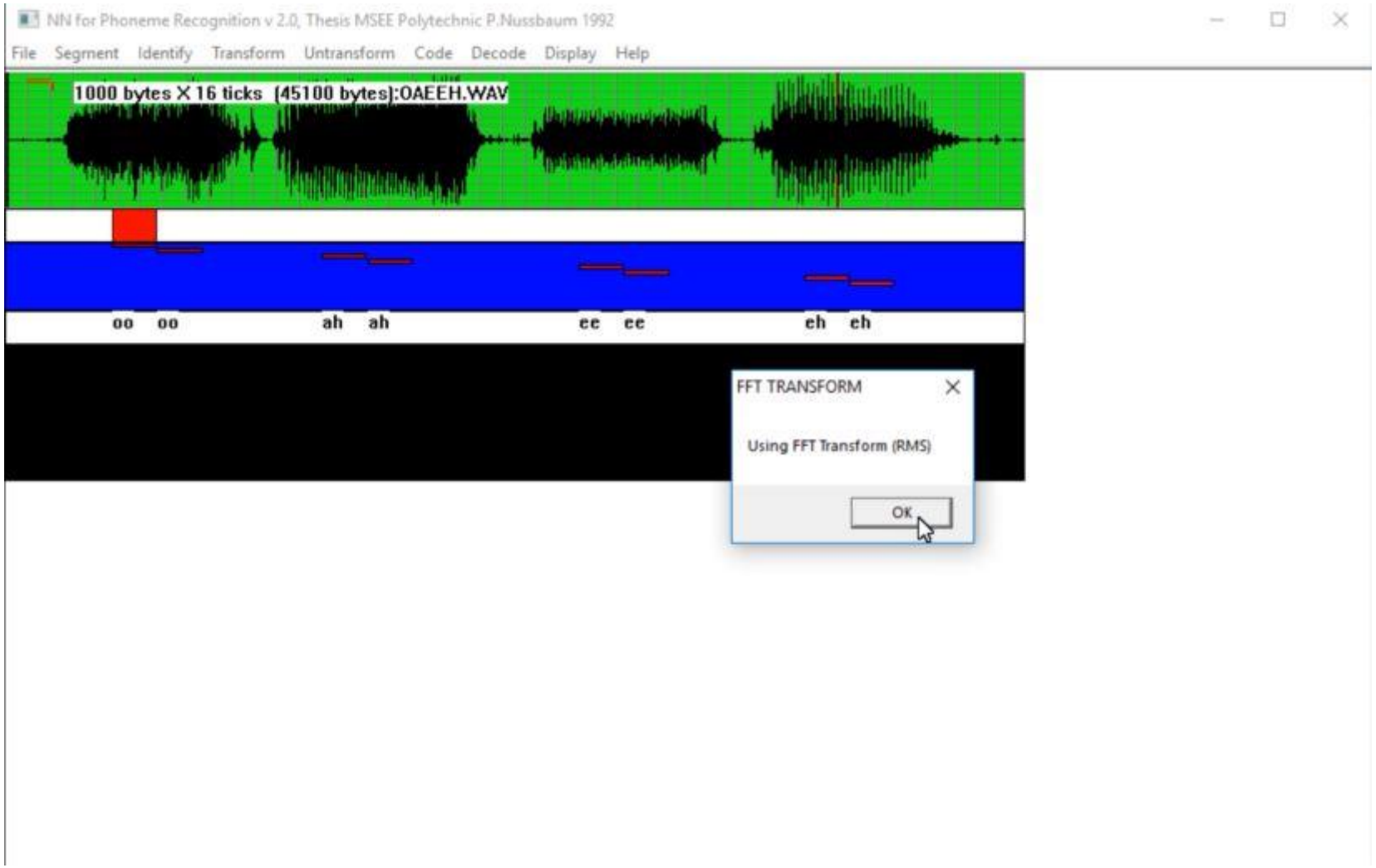
Now that the raw data has been segmented, it must be converted into a set of features. This transformation process is often very specific to the type of data and application, but in all cases, a good quality feature set can be extremely important.



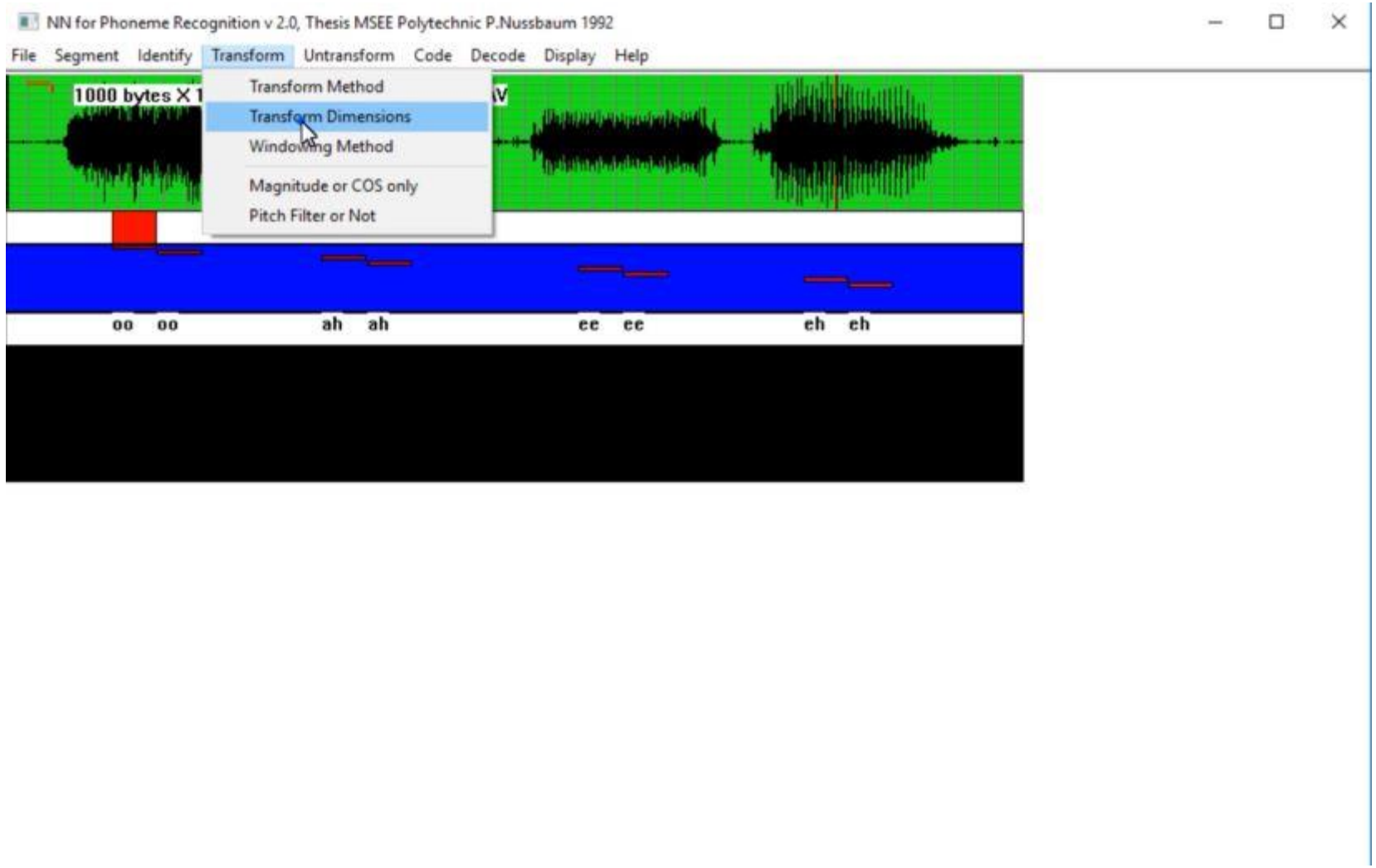
INTEGRAT allows the transformation process to be turned on or off.



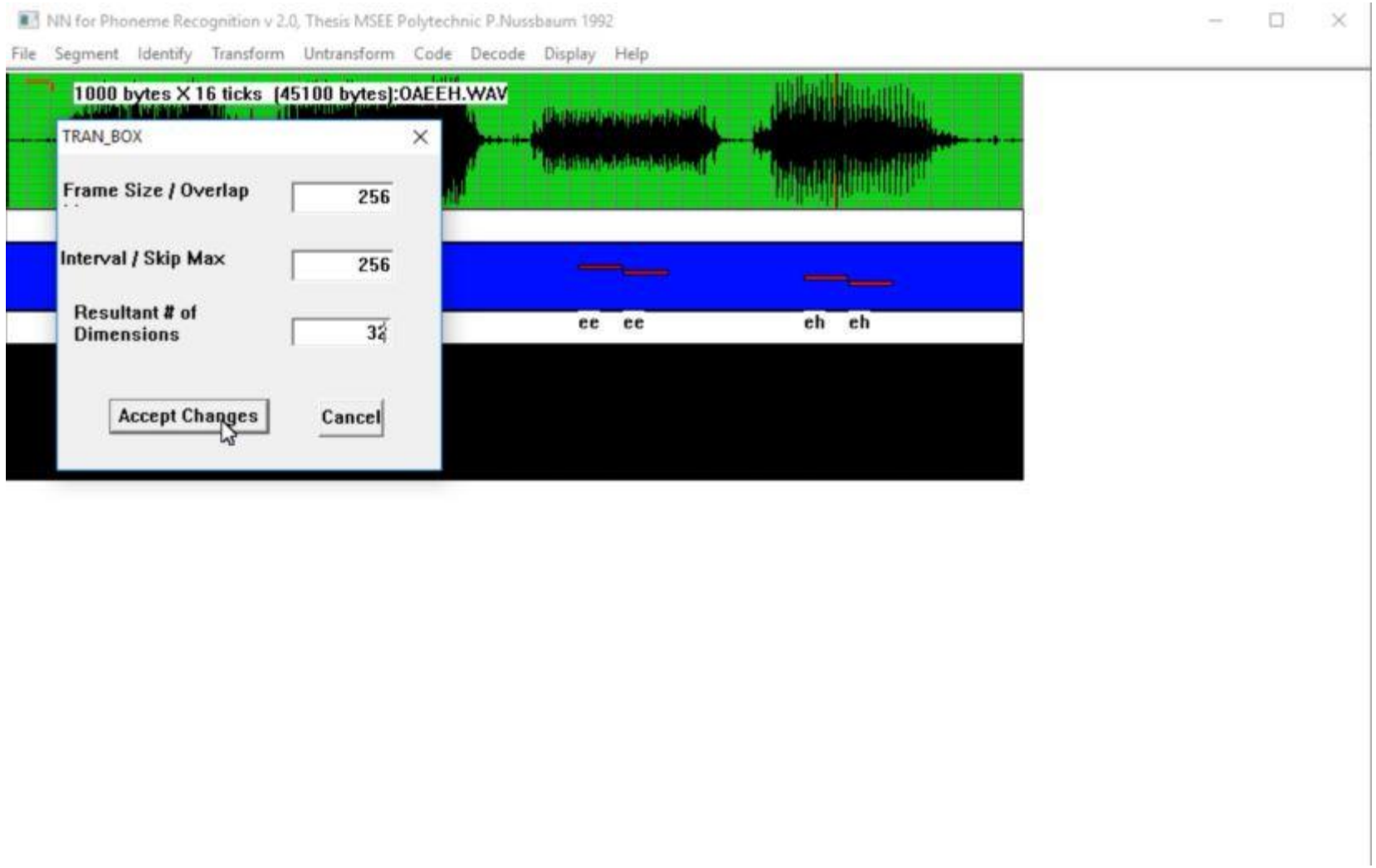
INTEGRAT first asks if Linear Predictive Coding (LPC) is to be used as the transformation method of feature extraction.



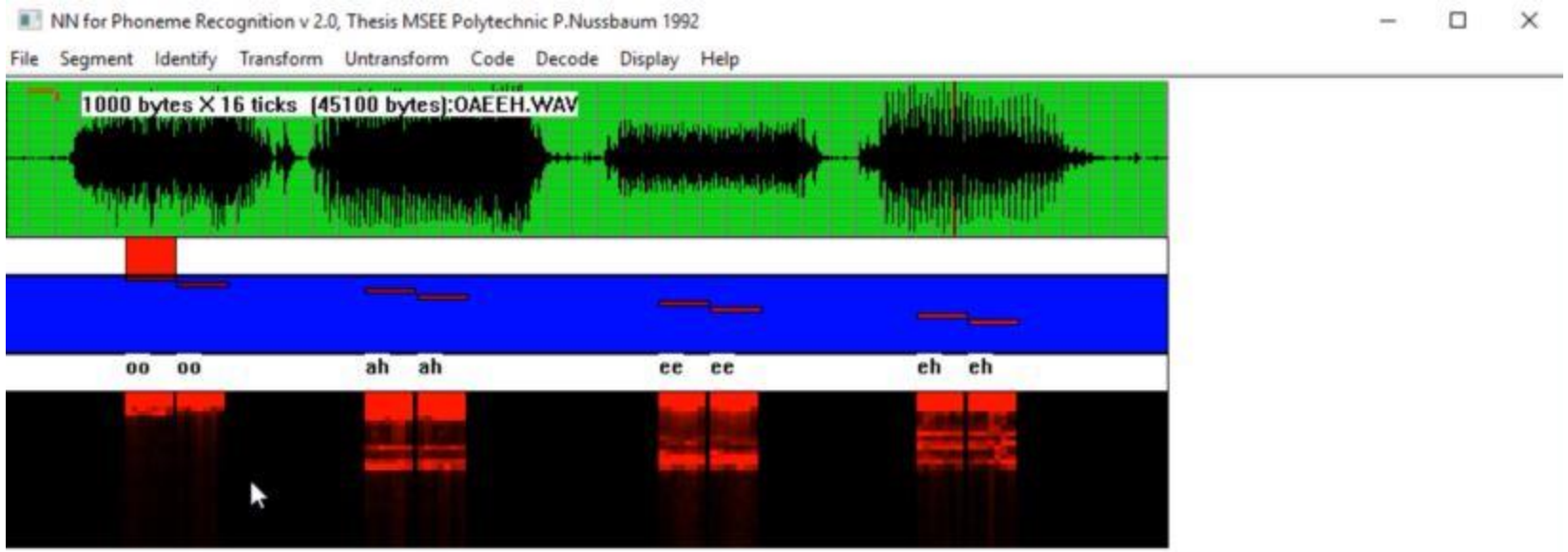
In this case, the user has selected a Fast Fourier Transform (FFT) as the feature extraction transformation algorithm.



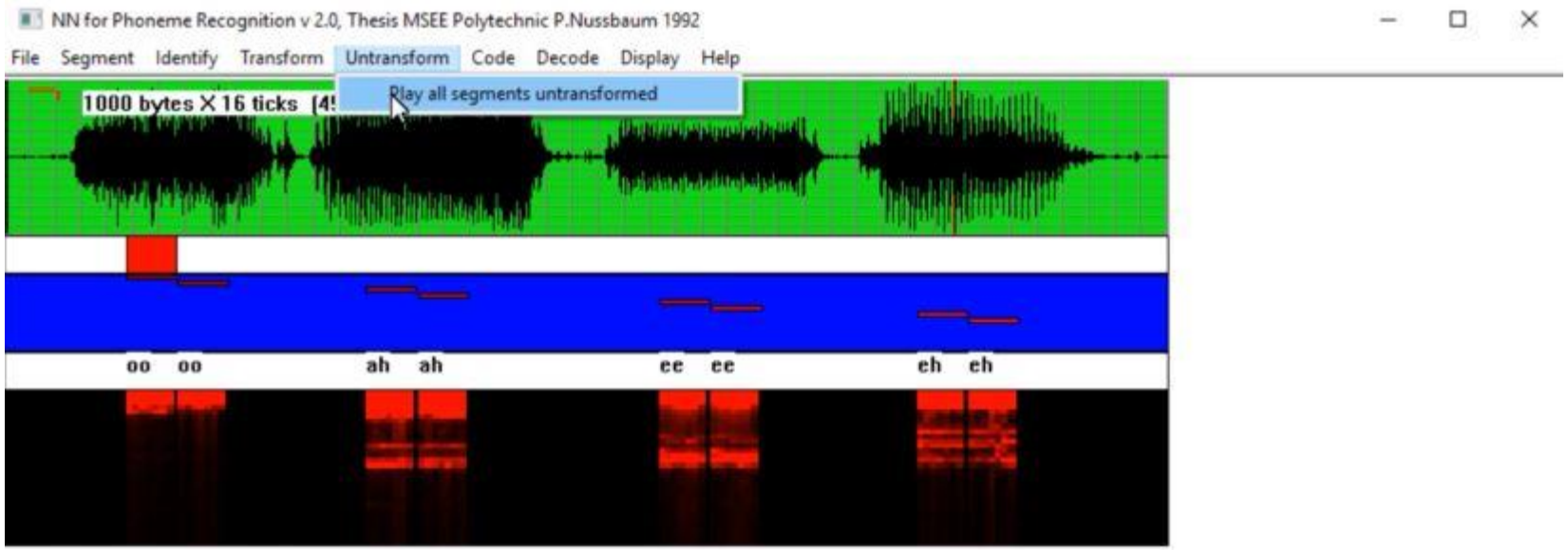
Most transformation algorithms require additional parameters to be selected.



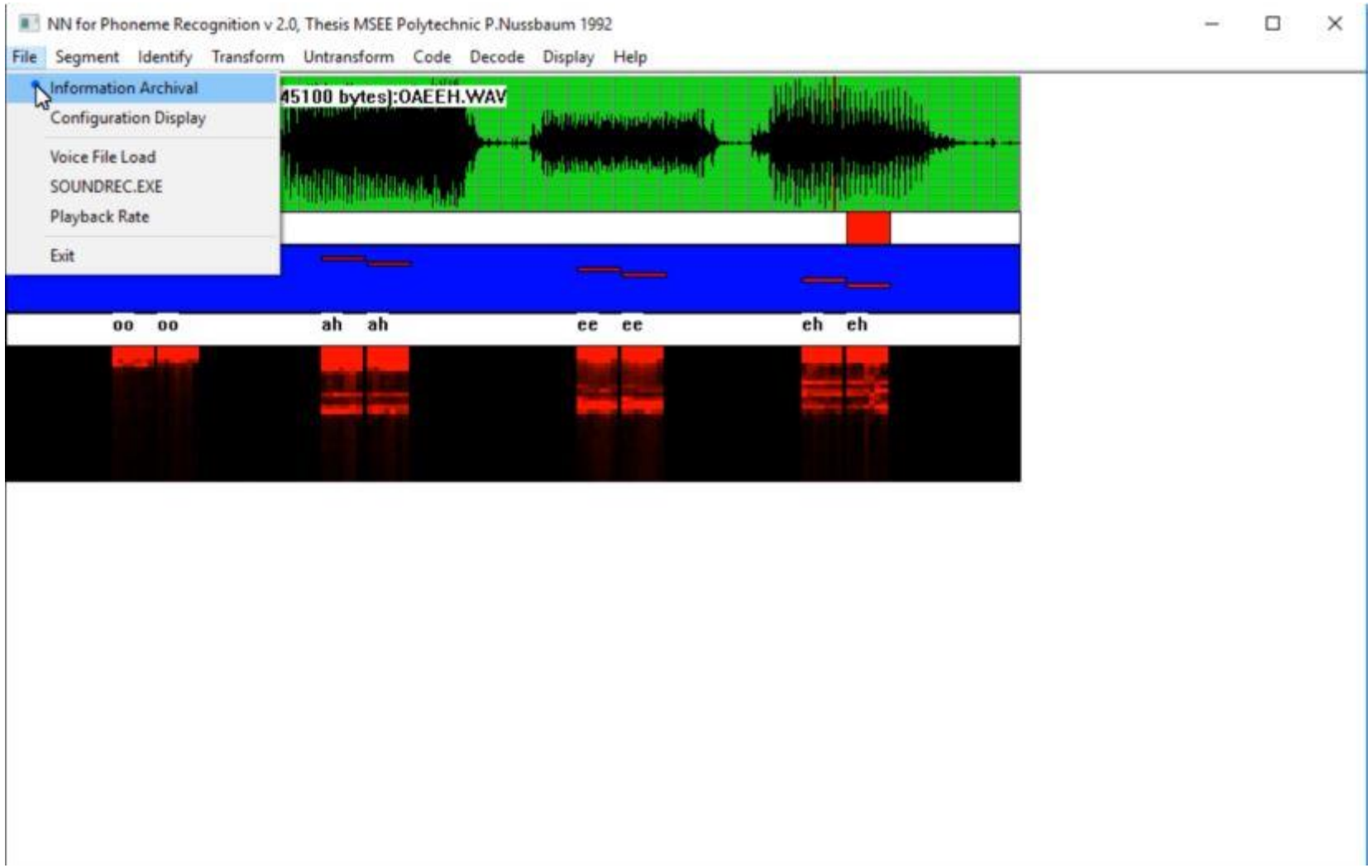
Here the FFT transformation algorithm parameters are being selected.



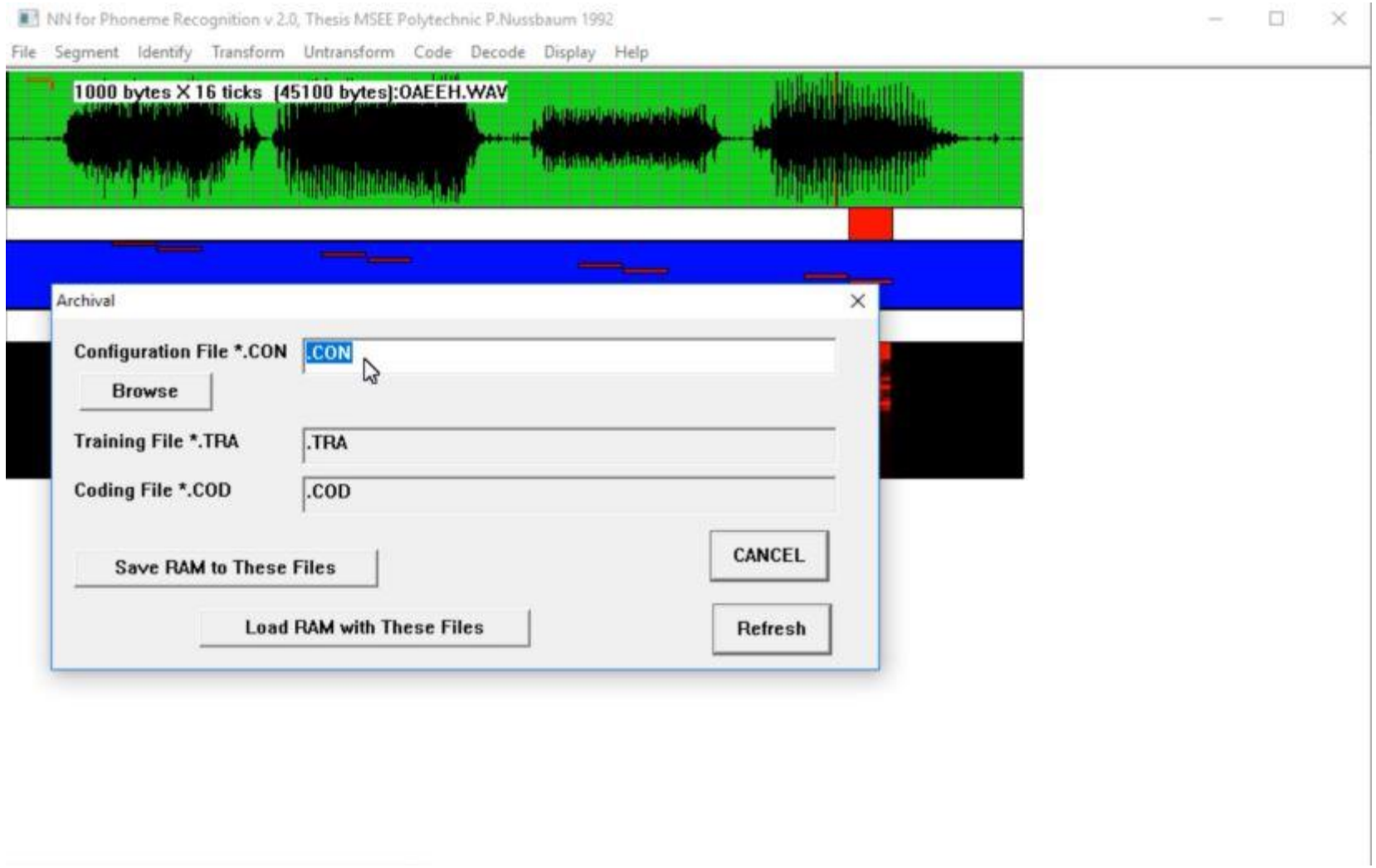
Below each segment are one or more vertical column vectors showing the features extracted by the transformation. In this case, the features represent vocal cord harmonics modulated by mouth and tongue. The human expert can visually see that feature vectors from the same identified data look similar, and that they also look different from different identified data.



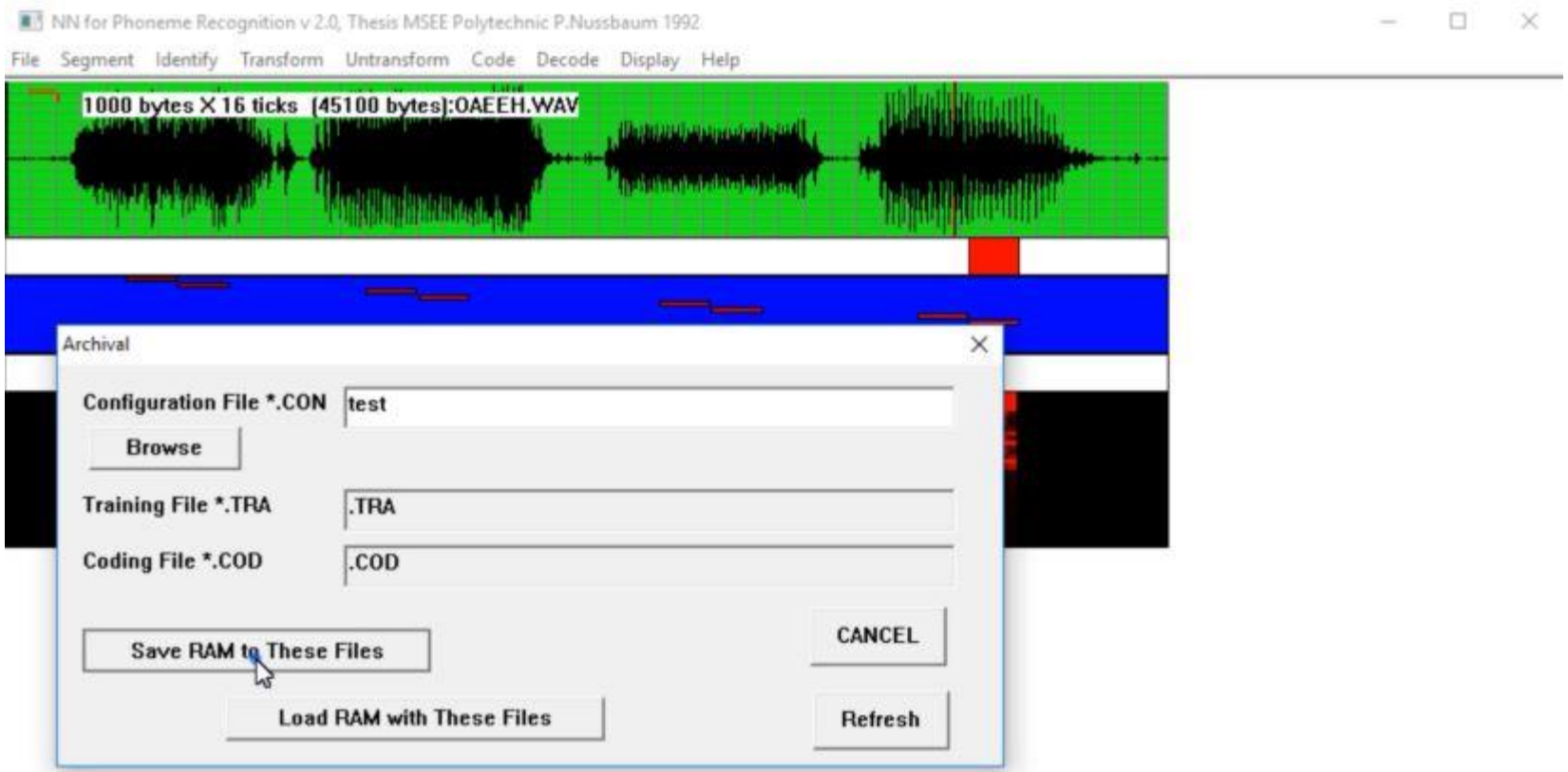
As per US Patent 5809462, INTEGRAT also performs an “UnTransformation” to see if the feature vector contains sufficient information for a human expert to tell the difference between them, and still make the correct identification. In the case of INTEGRAT, the Untransform provides an audio recreation of the vectors.



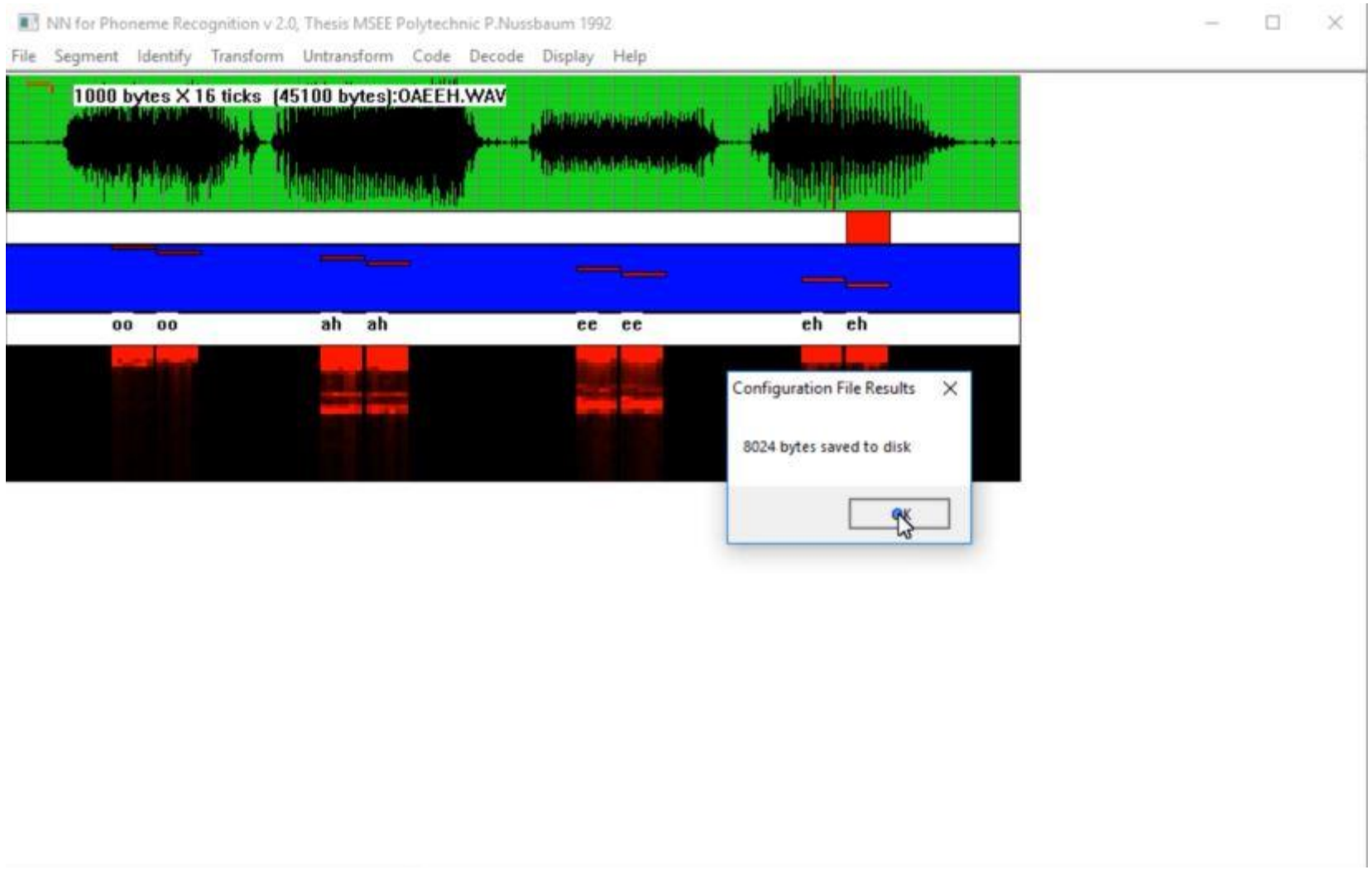
At this point, the user may wish to start saving the training set. INTEGRAT offers this information archival.



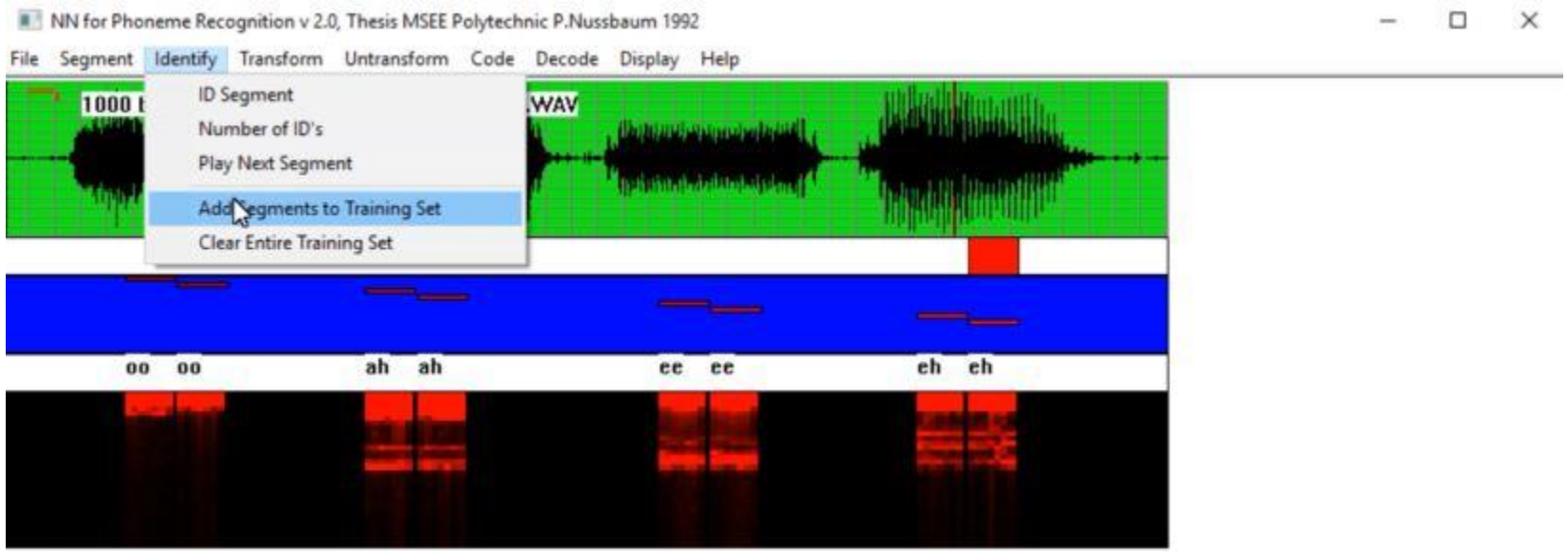
The .CON .TRA and .COD file suffixes are automatically added by INTEGRAT.



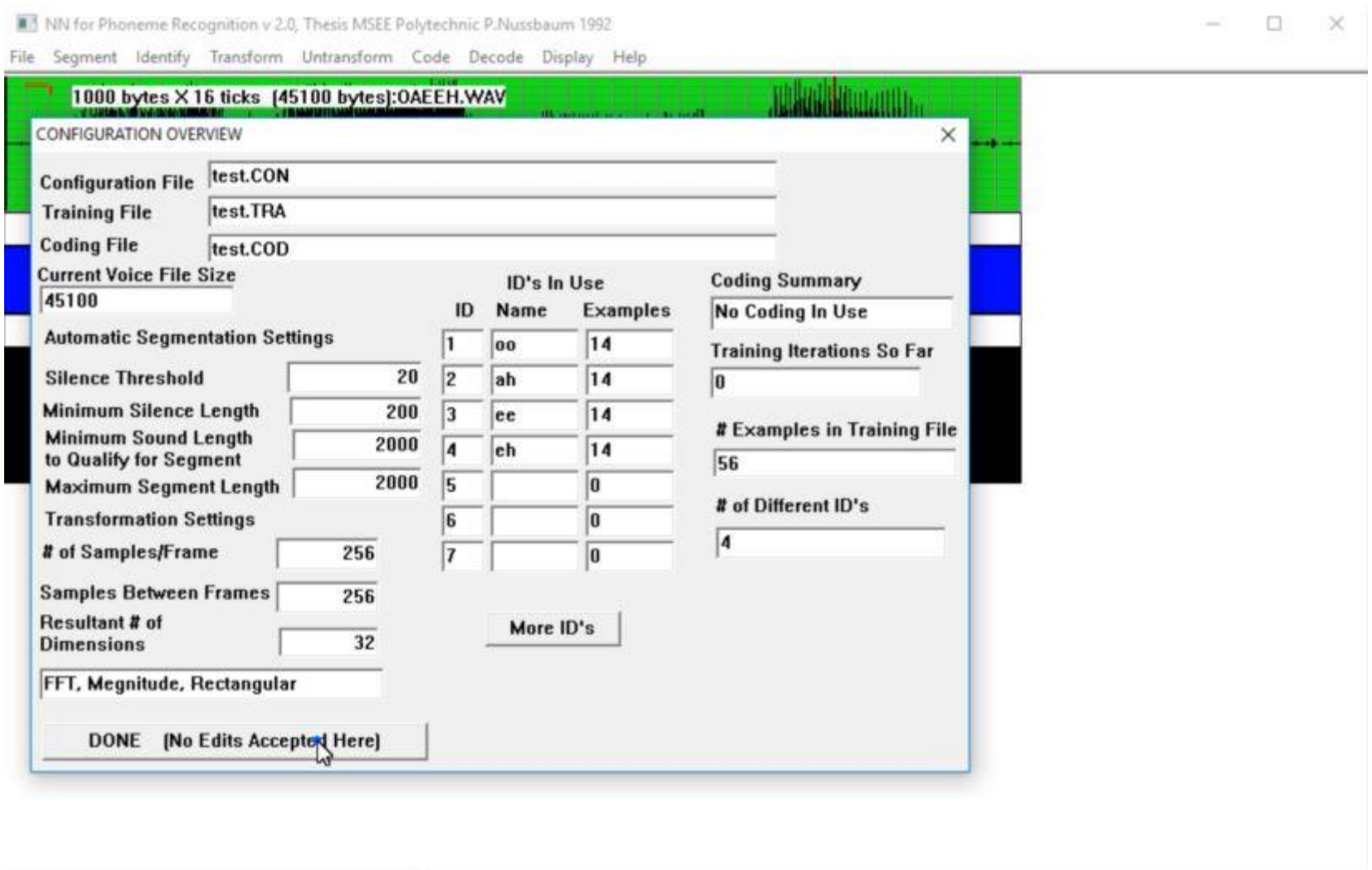
The user only needs to select a valid Windows filename (such as the word “test”) and then click Save.



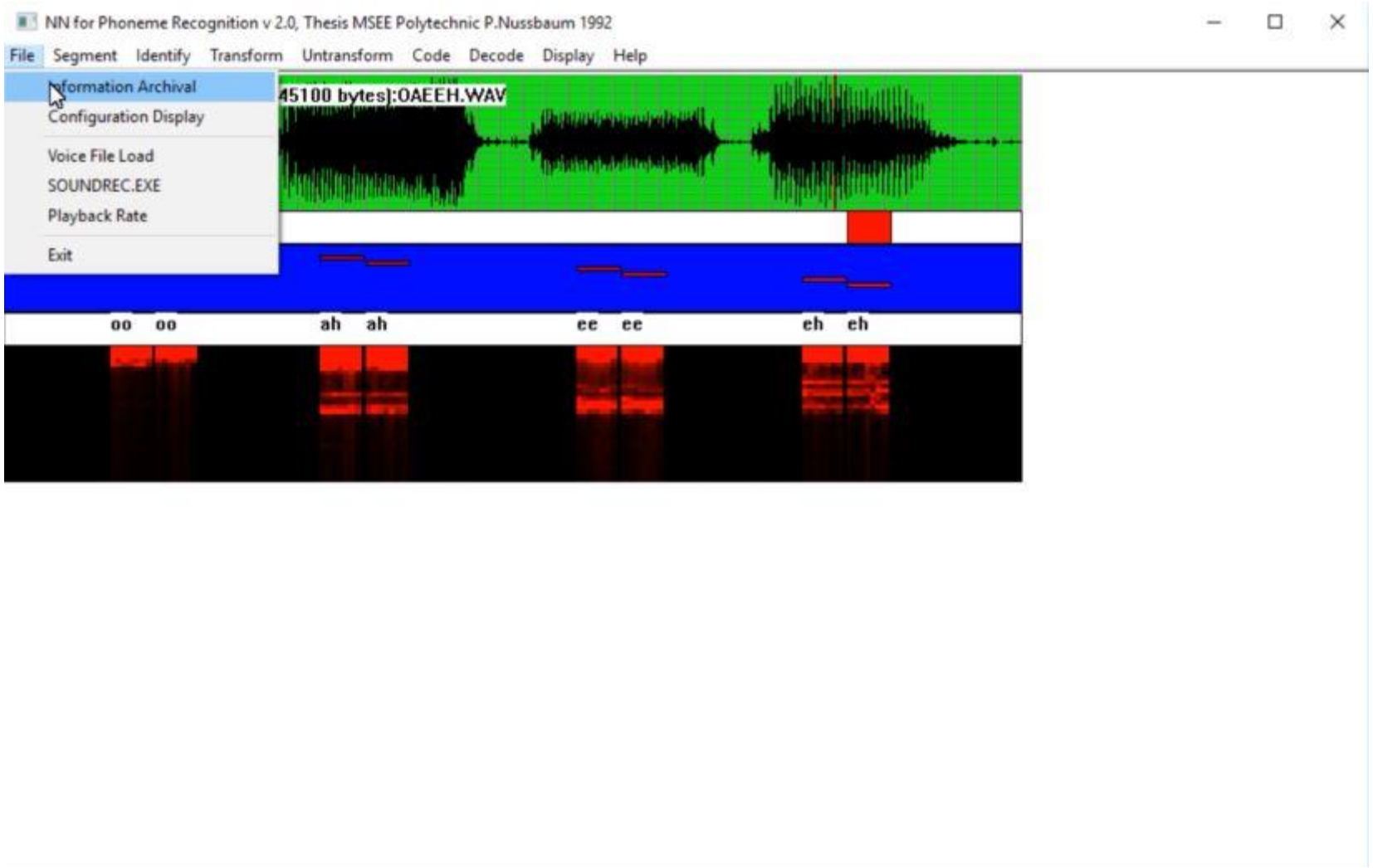
The data is automatically saved to disk, although there is still no Training or Coding information to save.



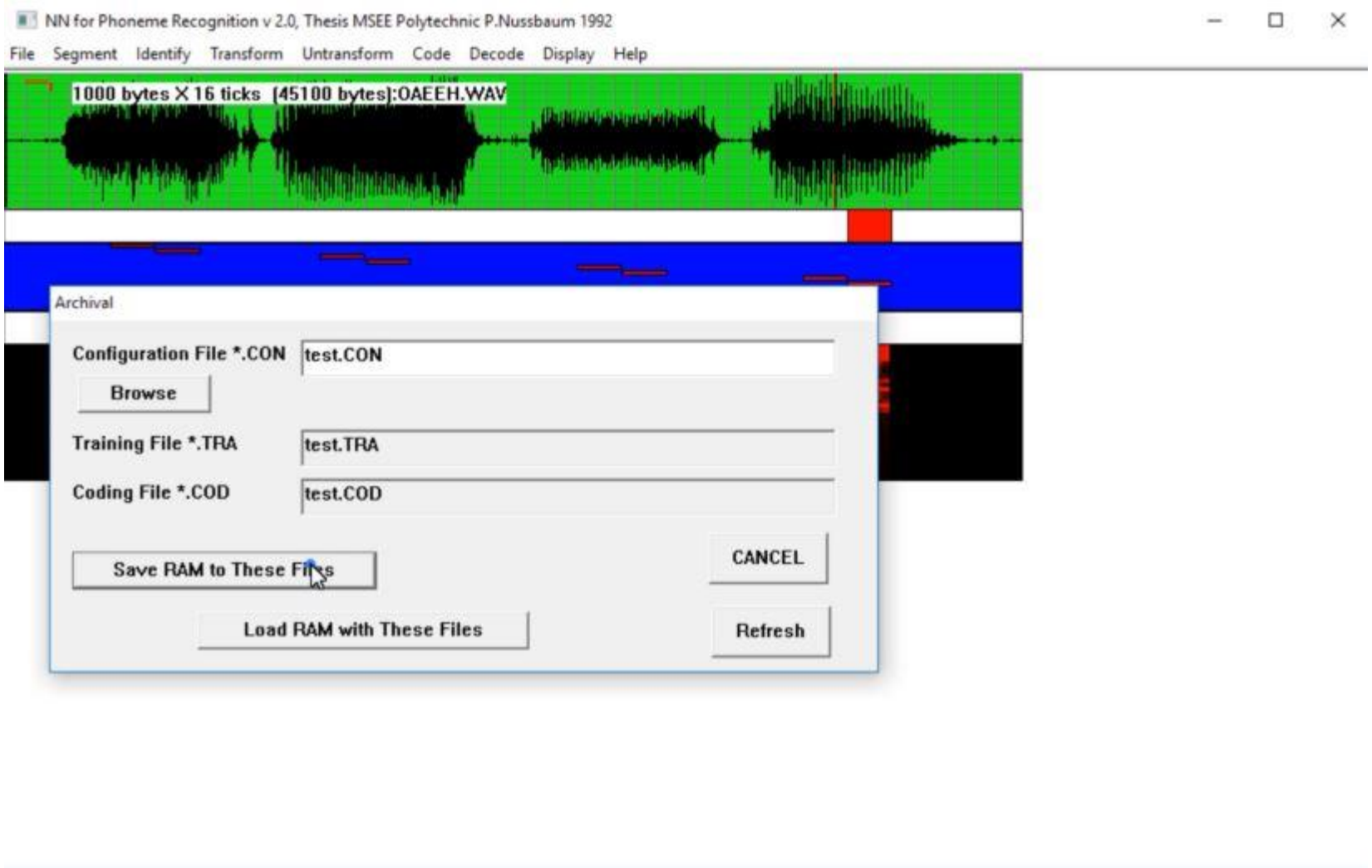
If the human expert is satisfied with the segments, their identification, and the transformation, then this group of segments can be added to the training set.



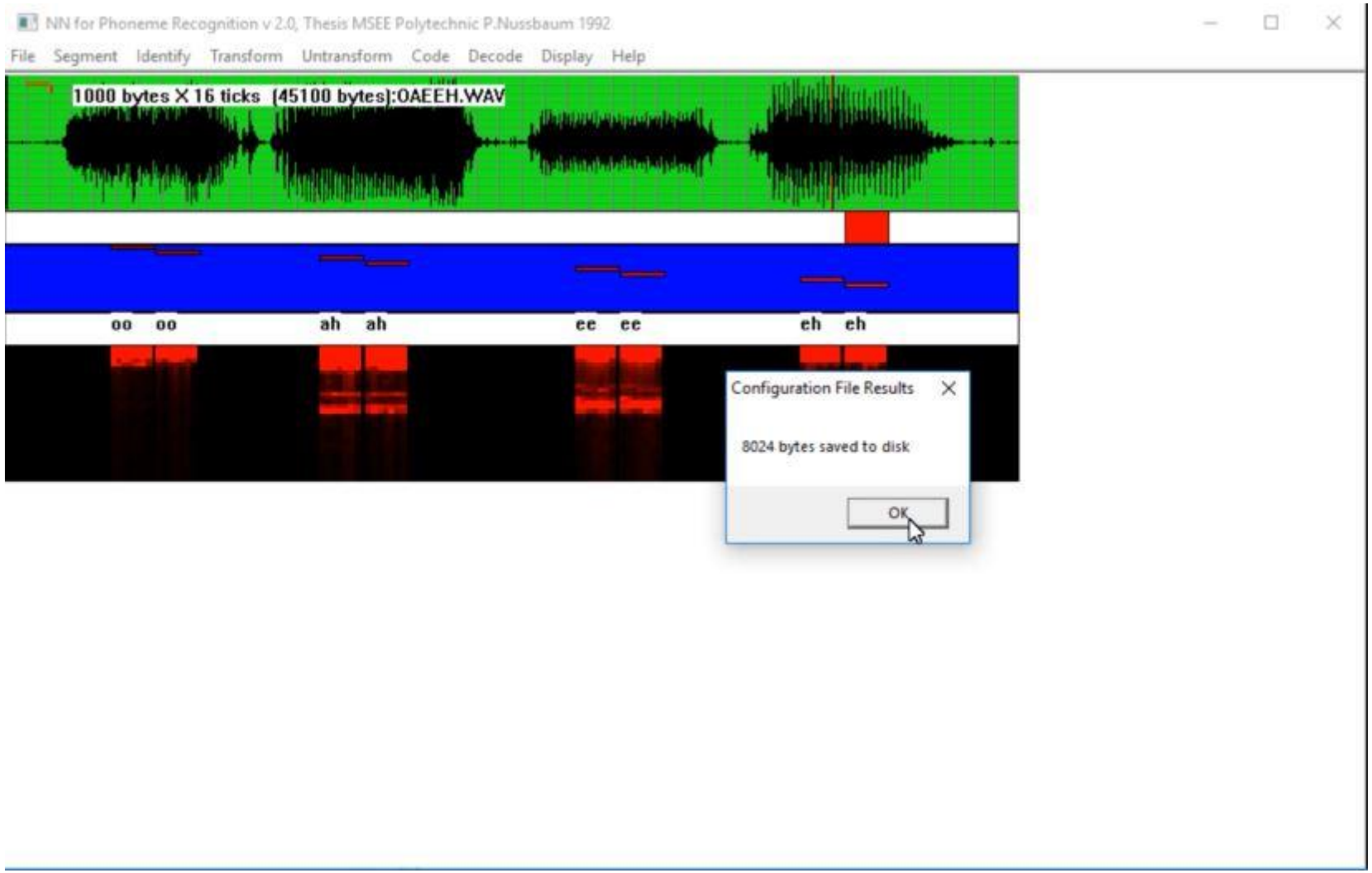
INTEGRAT then presents a complete summary of all of the configured parameters and data. Notice that the number of example vectors for each ID is the same (14). This can be important for unsupervised learning, where the AI robot can learn not only the different ID's, but also the likelihood of each.



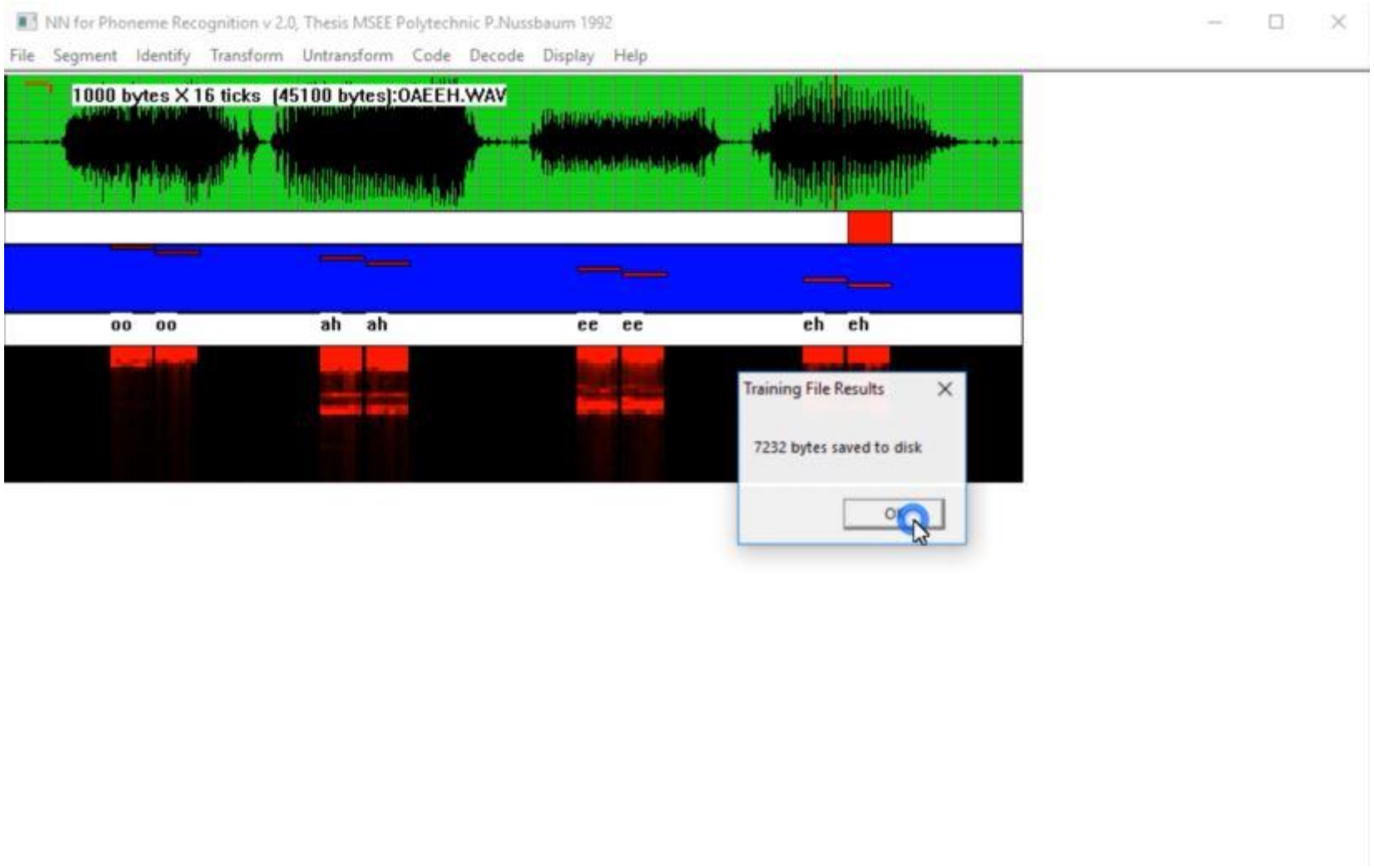
Since the human expert has added to the training set, the information should be archived to disk. This can be repeated over and over, as more and more data segments are added to the training set.



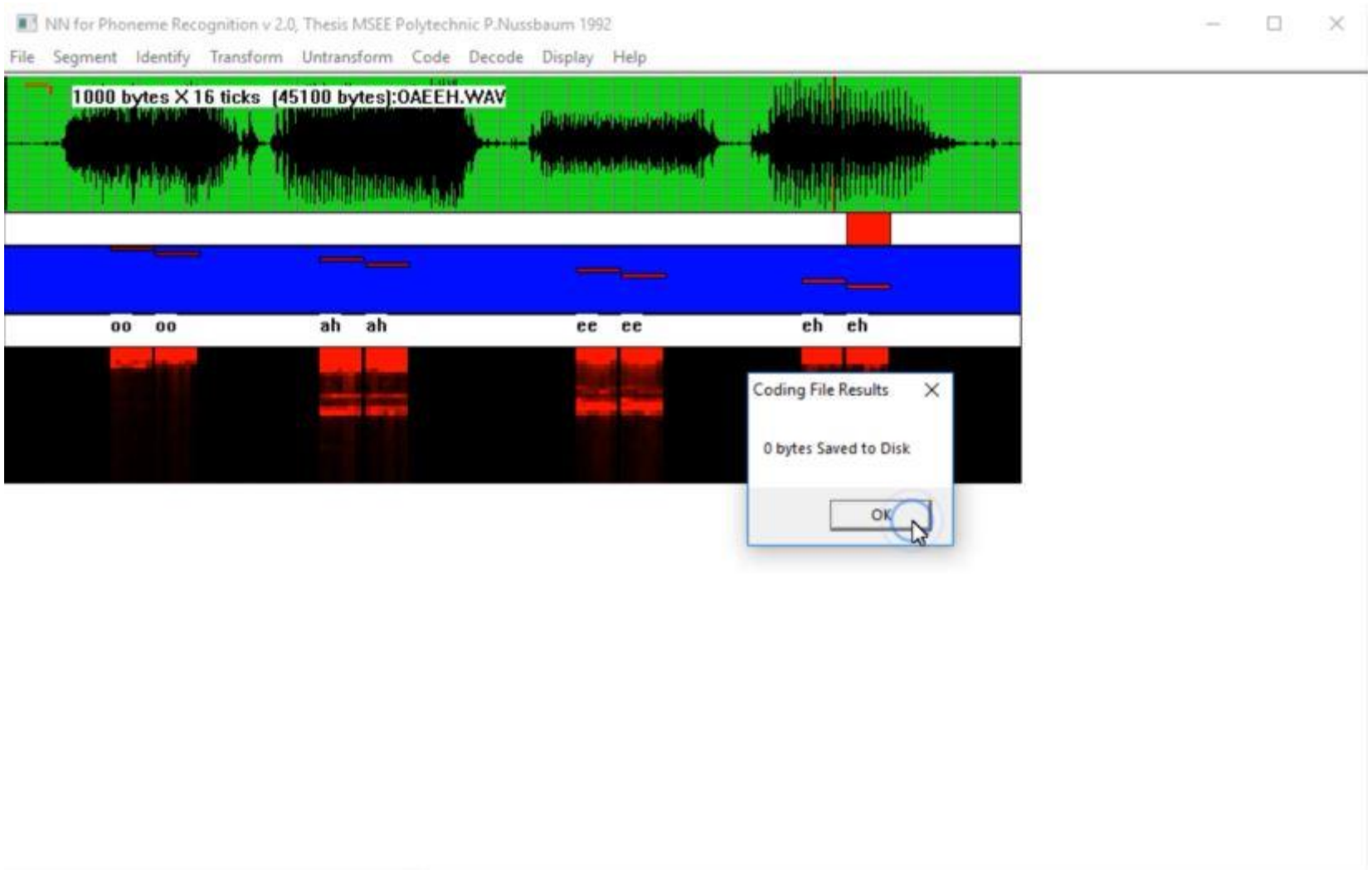
The previous filenames will be used again, unless explicitly changed.



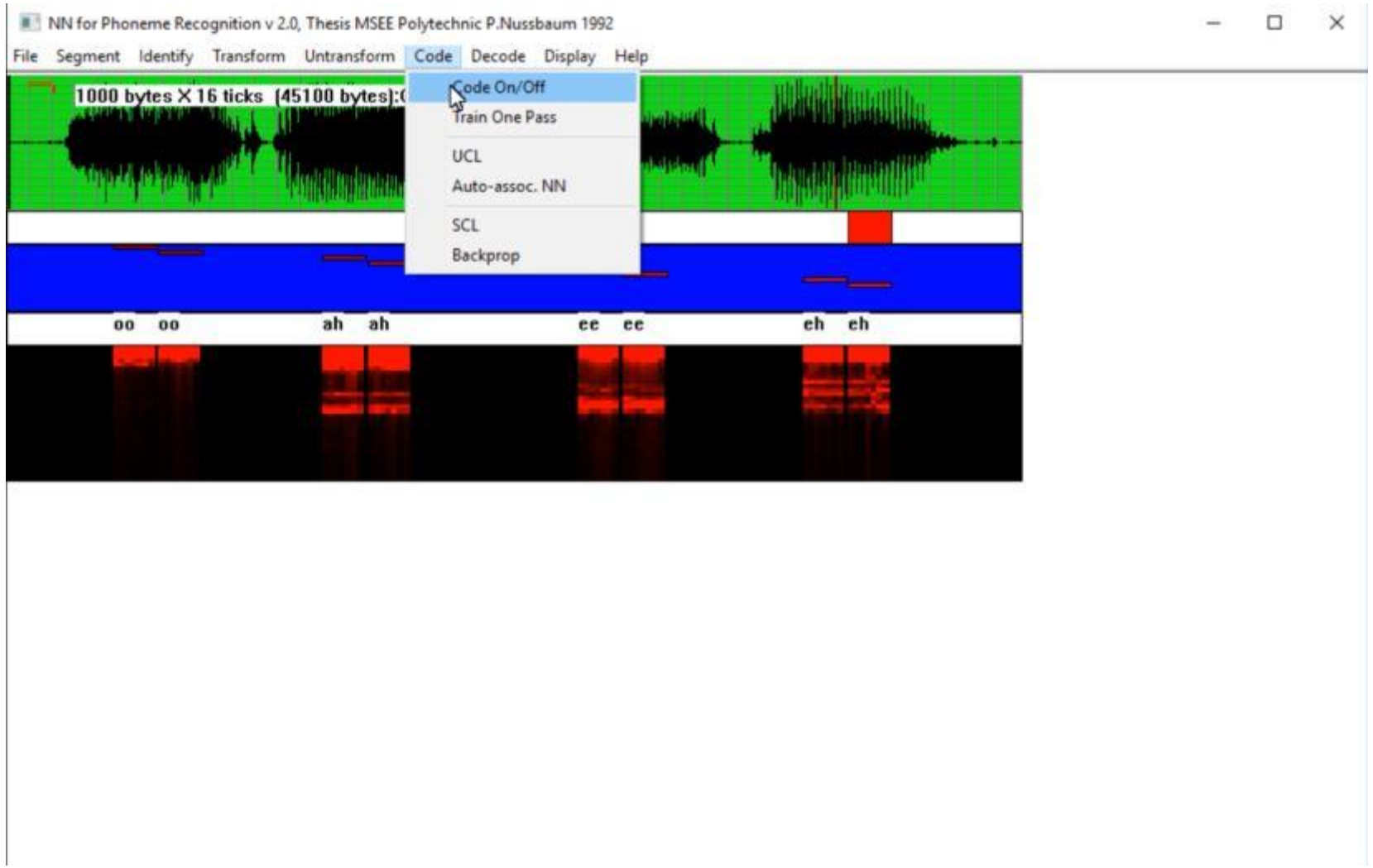
The configuration settings are saved in a very small file.



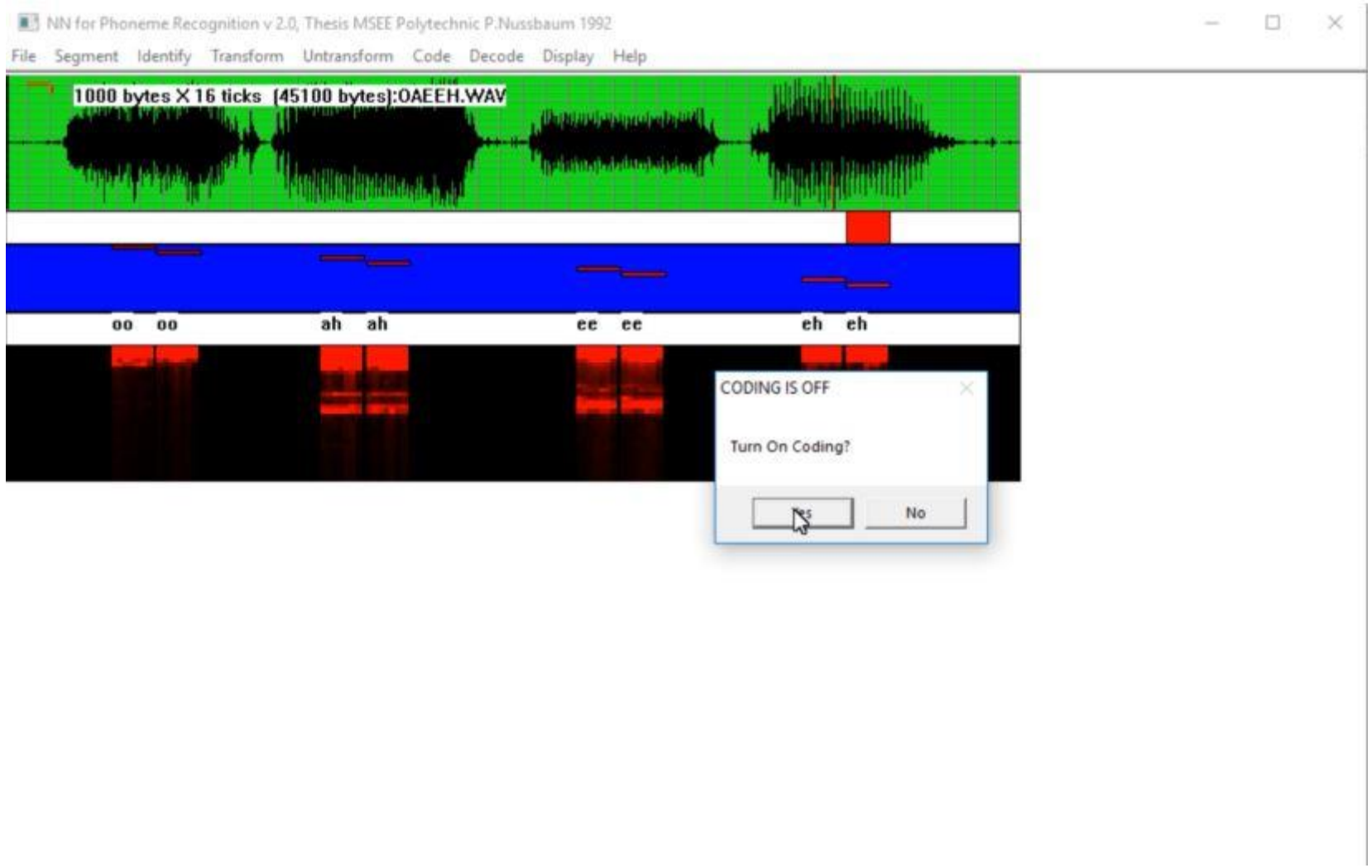
The training data will be saved in a file.



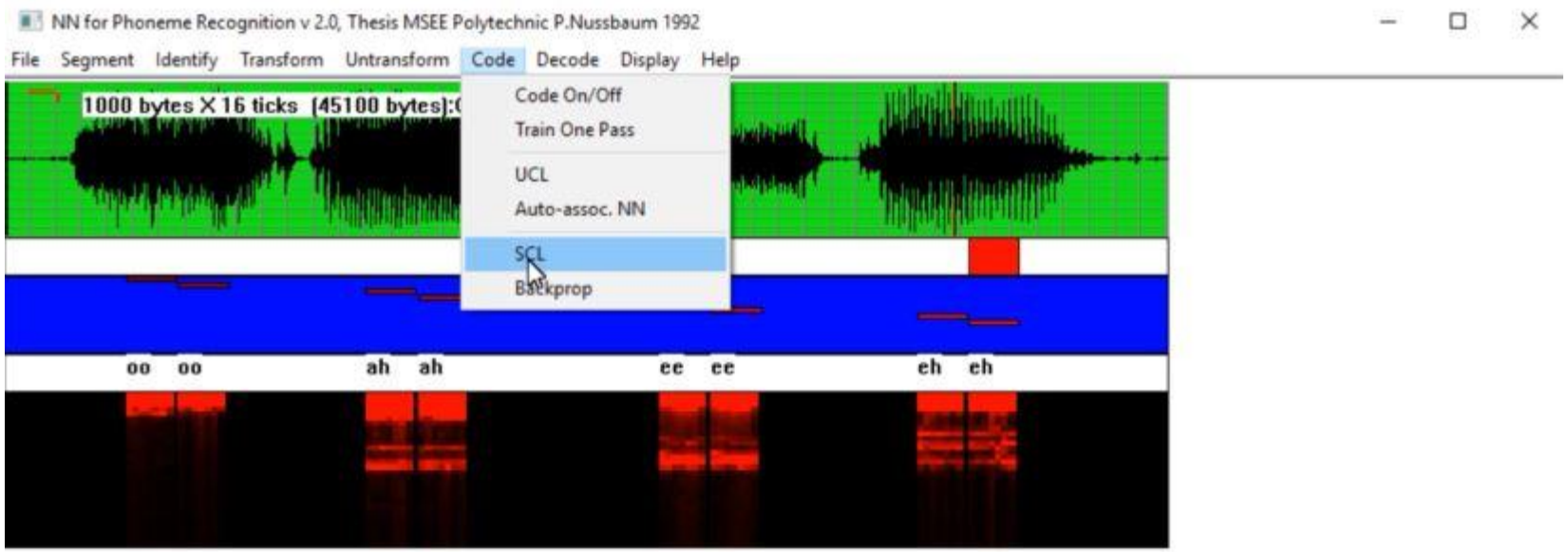
Finally, the trained AI robot coding parameters are saved. Since no training has taken place yet, there is nothing to save.



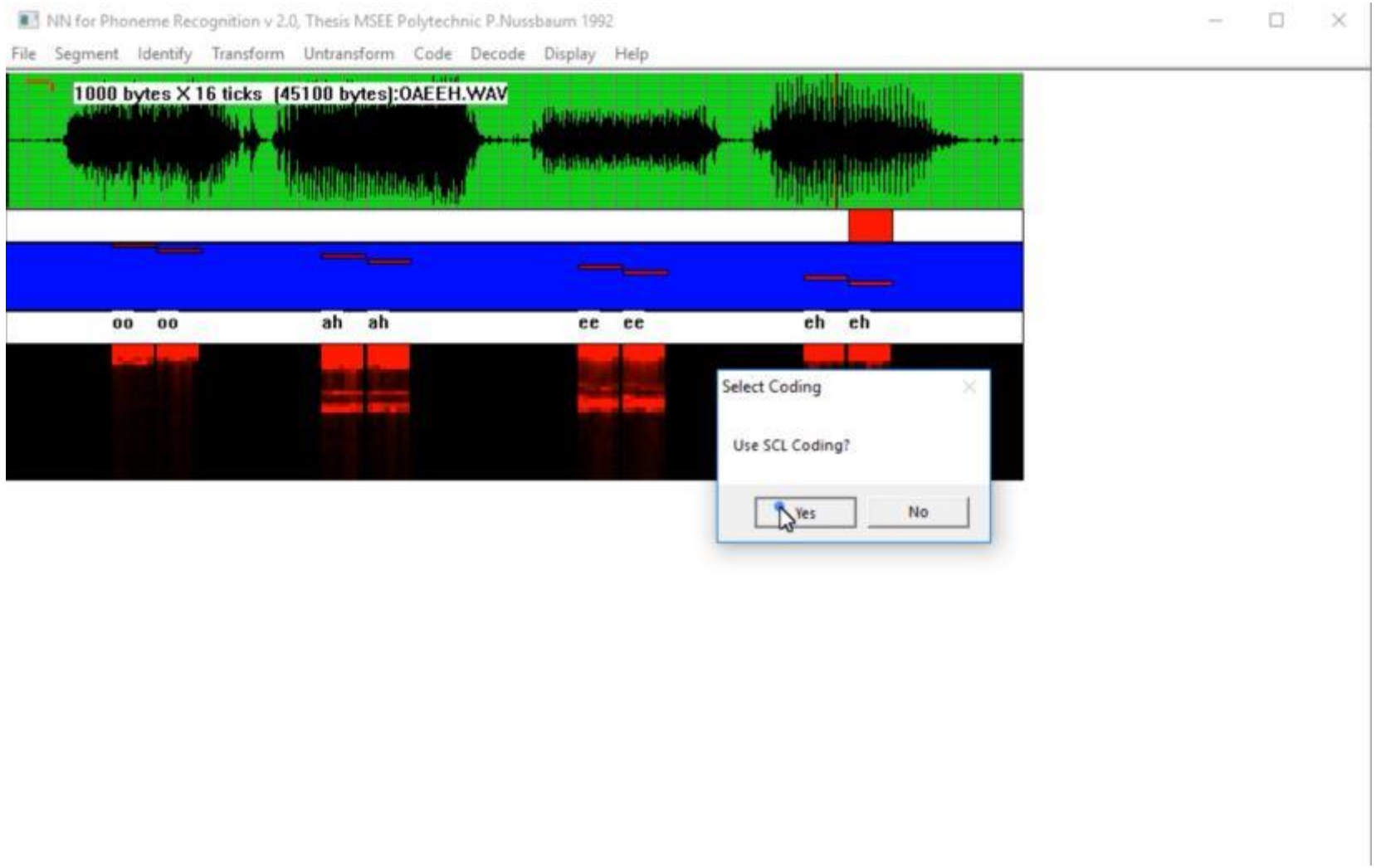
Now comes time to use the training data to create an AI robot. INTEGRAT calls this step the “Code” step. The INTEGRAT AI robot will attempt to examine each feature vector and identify it with a code, based on its training.



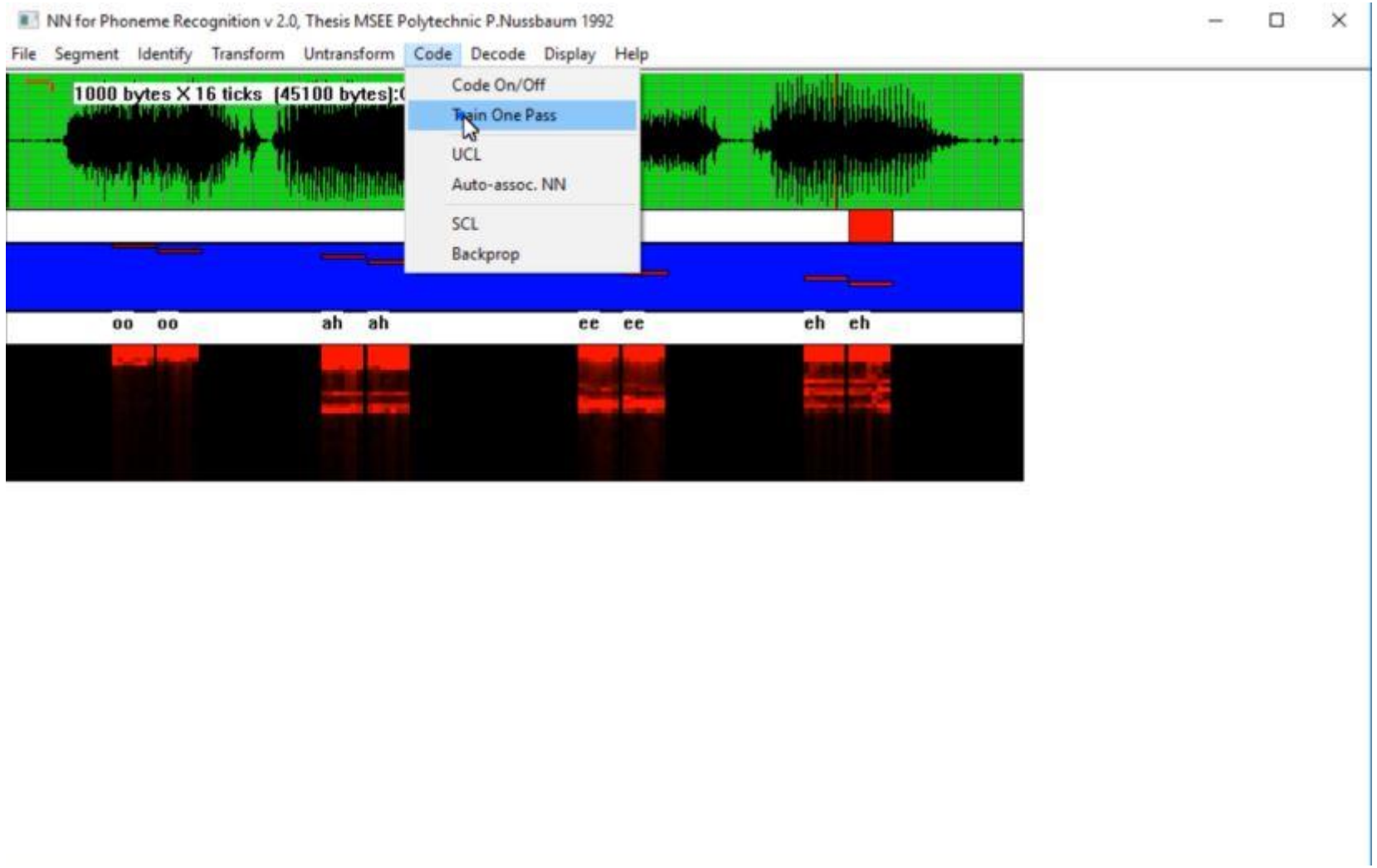
INTEGRAT allows the coding functionality to be turned on or off.



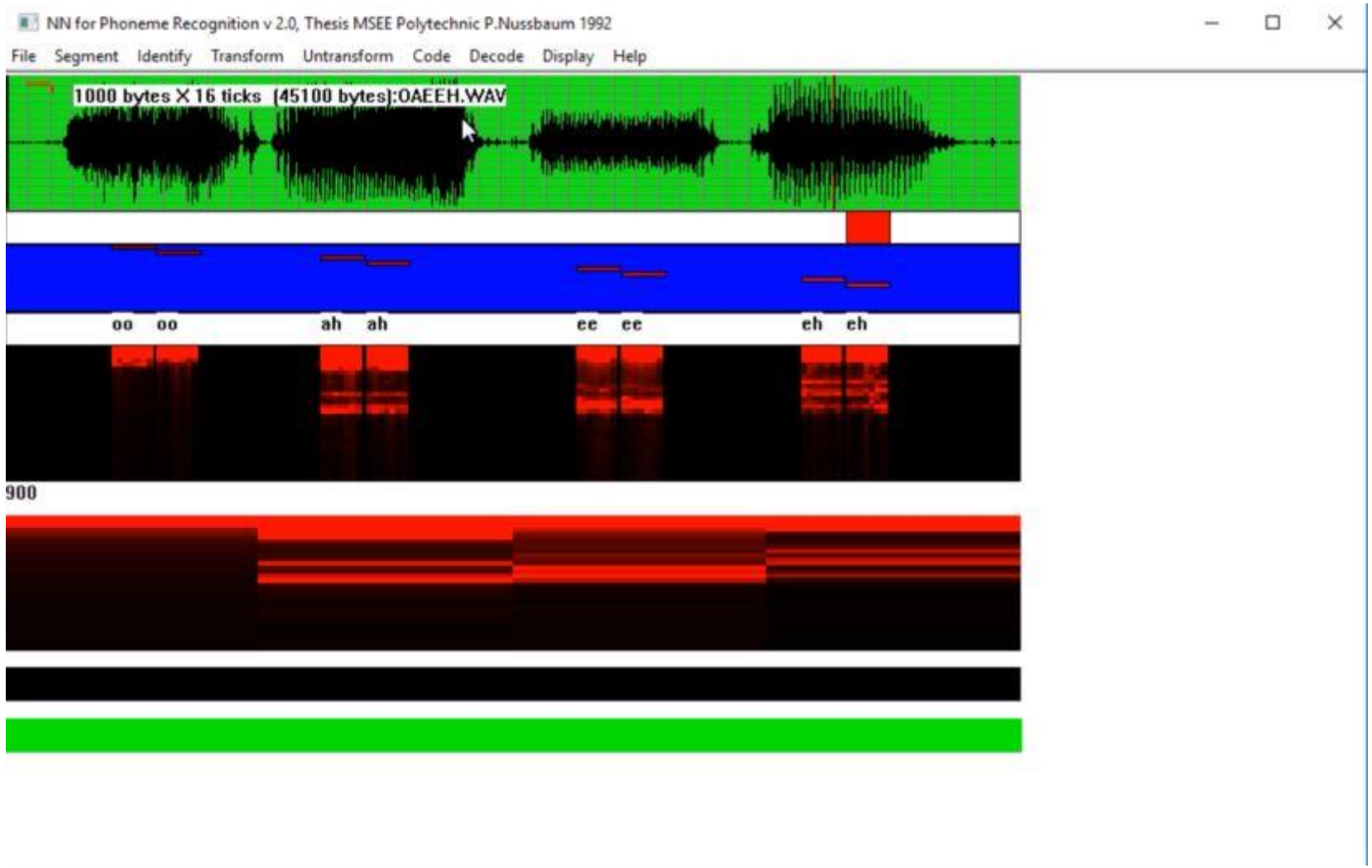
INTEGRAT offers four different kinds of coding. Unsupervised Competitive Learning (UCL) and Auto-associative neural networks both ignore the human expert's manually inserted ID values, and instead try to simply look for patterns. The other two kinds of coding, Supervised Competitive Learning (SCL) and Back-Propagation neural networks try to learn the "correct" ID numbers.



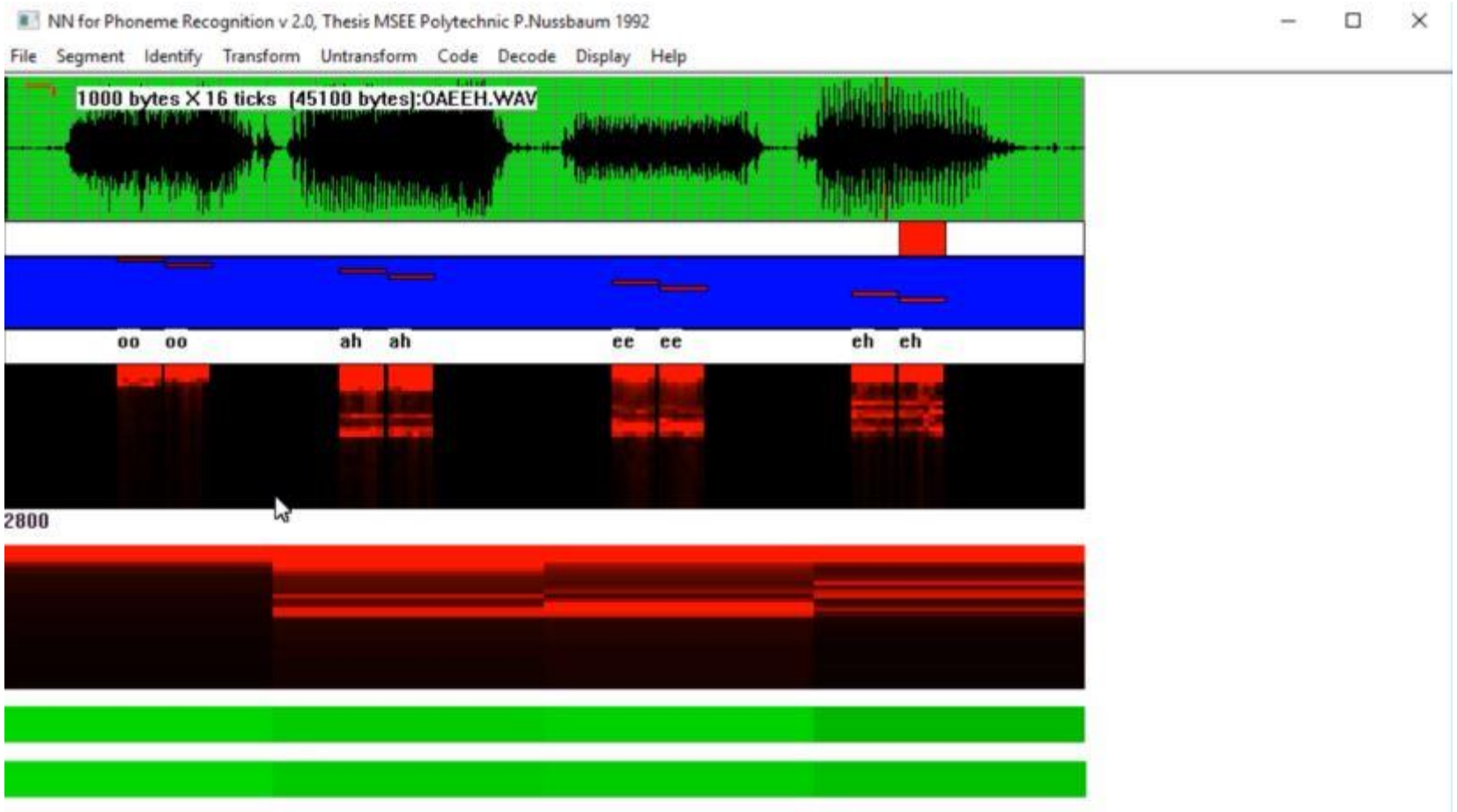
Here the user has selected SCL coding. Both SCL and UCL slowly train to find optimal “centroids” of the data provided. The neural networks, on the other hand, adjust connection weights to slowly minimize an error value over repeated training.



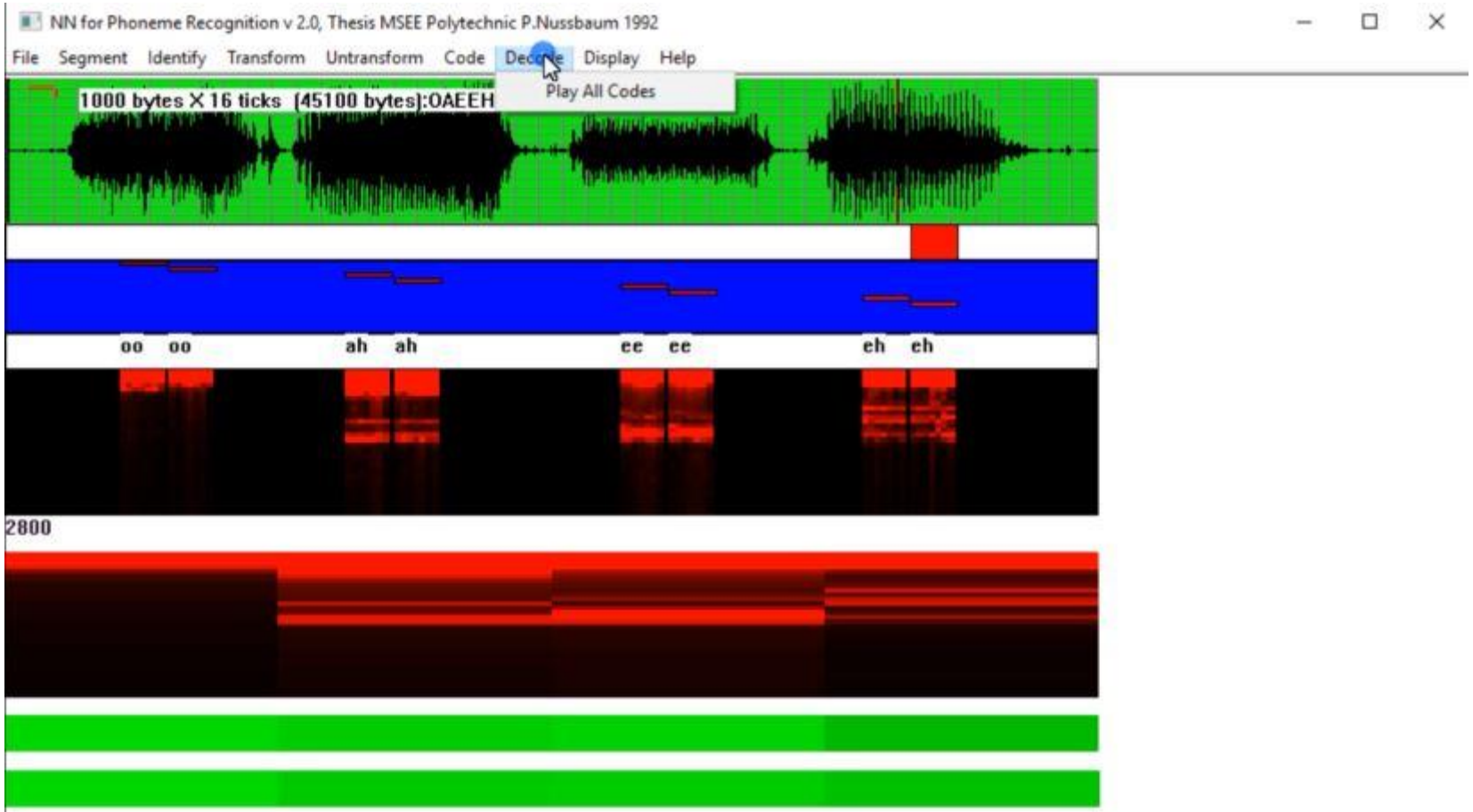
Once coding has been selected, training can begin. INTEGRAT divides training into “passes” which are a fixed number of training iterations, presenting random entries from the total set of vectors in the training set.



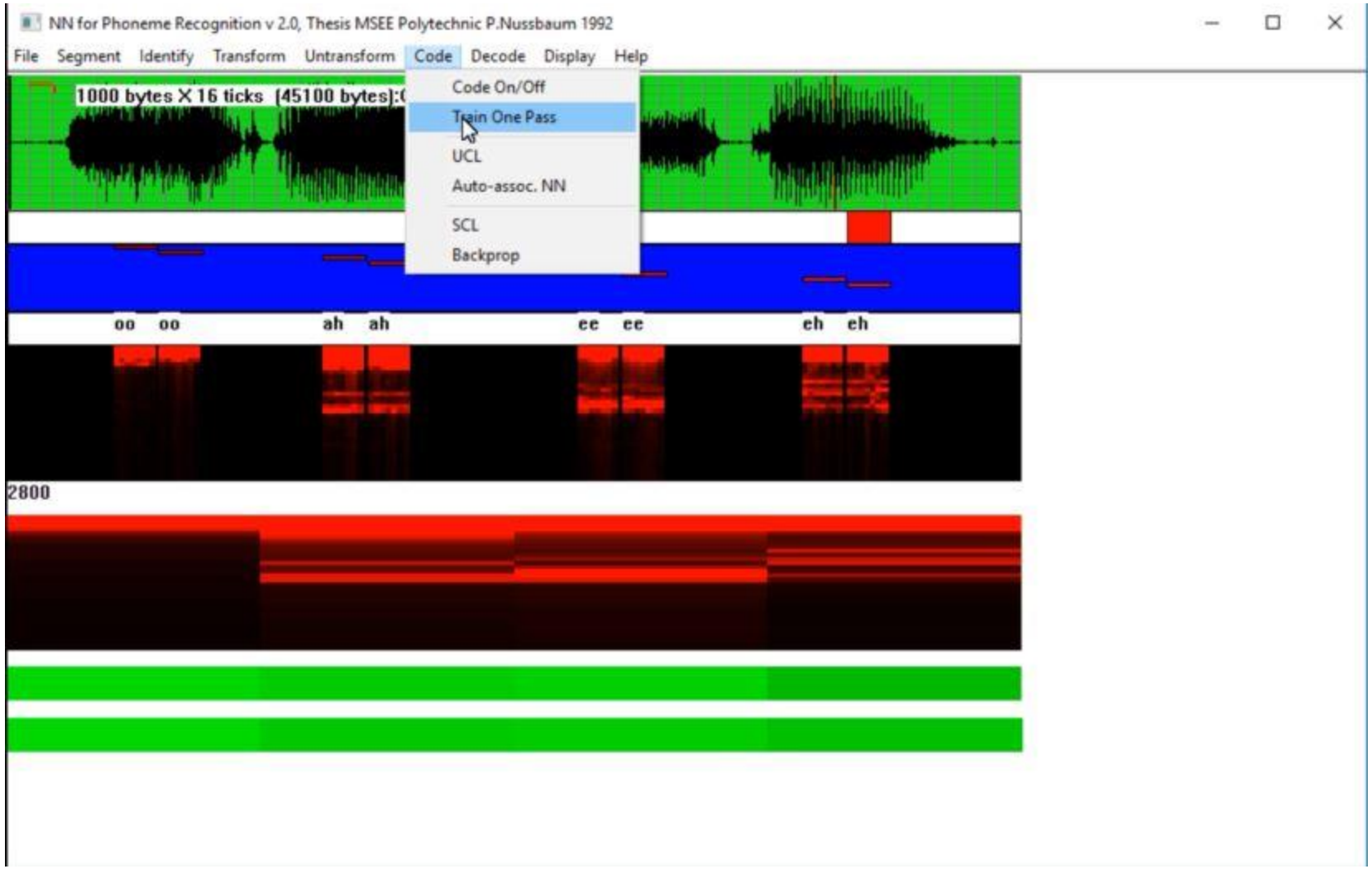
Here we see that a training pass is underway (so far, it has presented 900 randomly selected training vectors). Below the segment vectors, we can see the robot's internal "exemplary" vectors for each ID. Each of these 4 wide column vectors should look similar to the vectors of the ID's they represent.



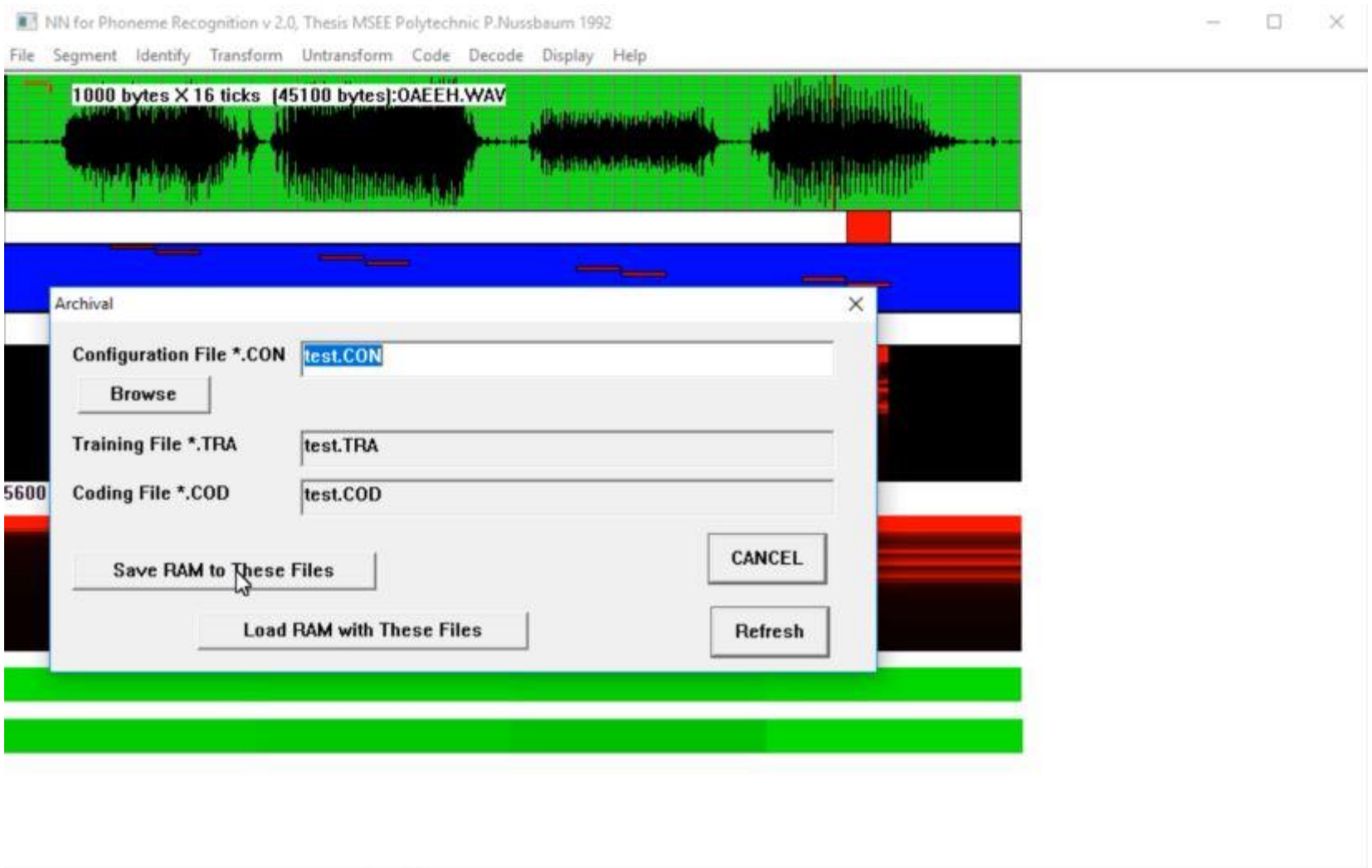
Here a complete single training iteration is finished (2800 randomly selected training vectors were presented). The green horizontal bars represent the number of times the AI identified each ID, and the number of times each ID was presented for training, respectively. The green bars are pretty much the same brightness, since we had an equal number of training examples for each ID, as would be expected.



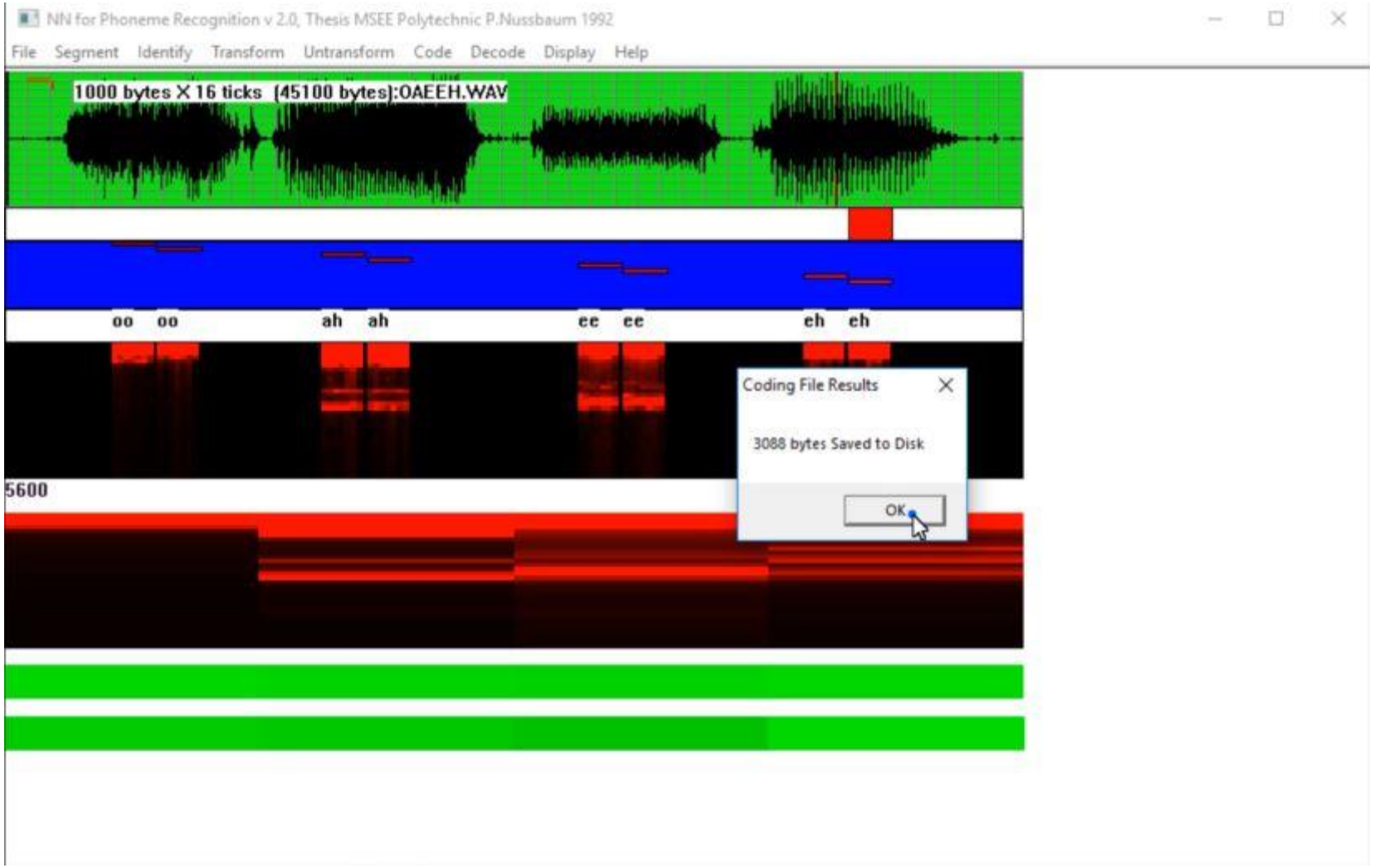
As per US Patent 5749066, INTEGRAT attempts to identify the exemplary vectors for each ID by examining the internals of the AI robot mind (different for each coding algorithm). This is called “DeCoding” and in the case of phonemes, can also be converted to audio. By using Decoding to read the robots mind, the human expert can see and hear what the robot imagines a phoneme vector should look and sound like.



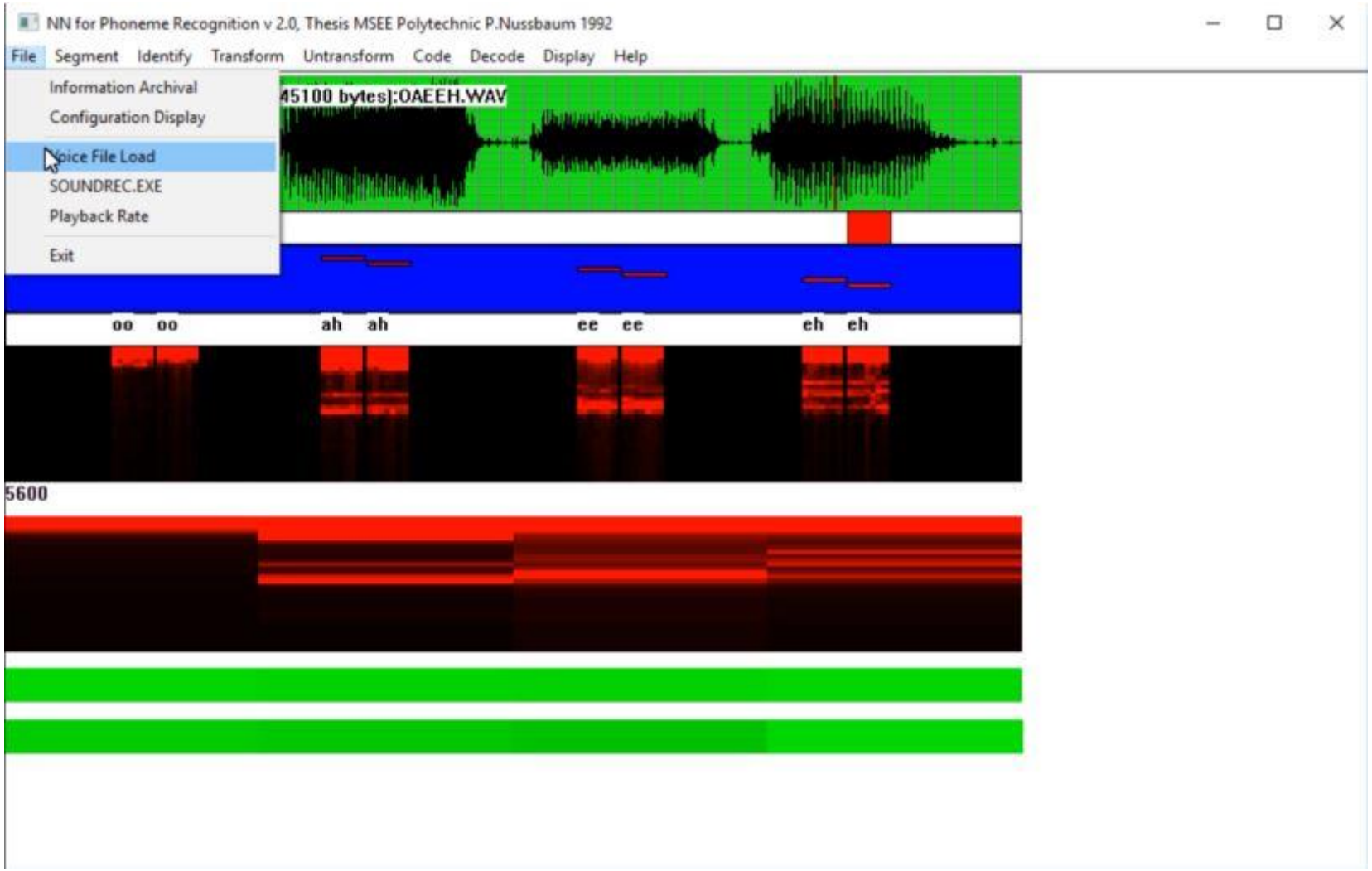
Additional training passes can be conducted to improve the AI robot performance, although excessive training can sometimes backfire (causing the AI robot to learn only the training set, and not be able to handle the real world variations).



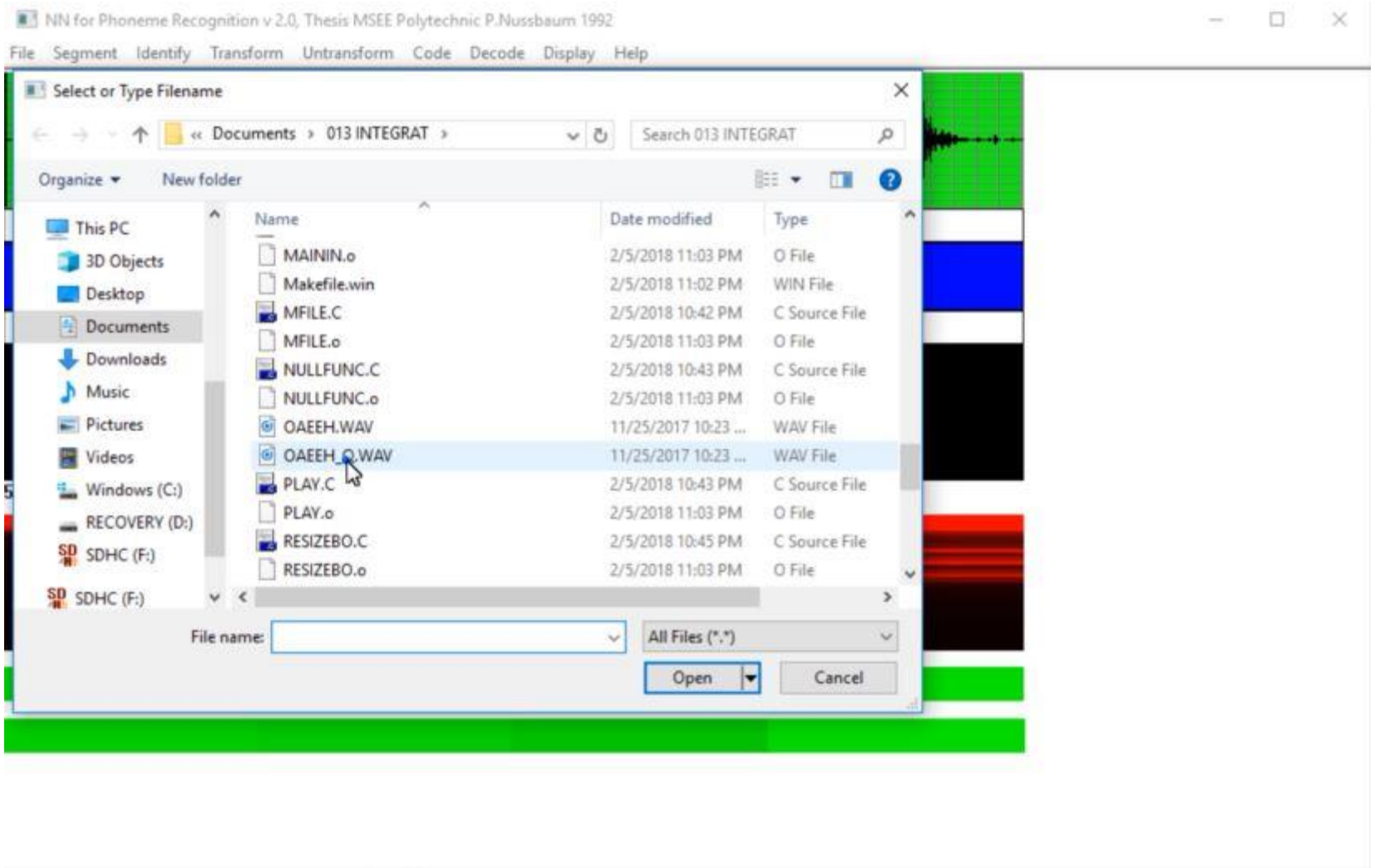
Once the human expert has determined that the training is yielding sufficiently good quality results, the entire work can be saved.



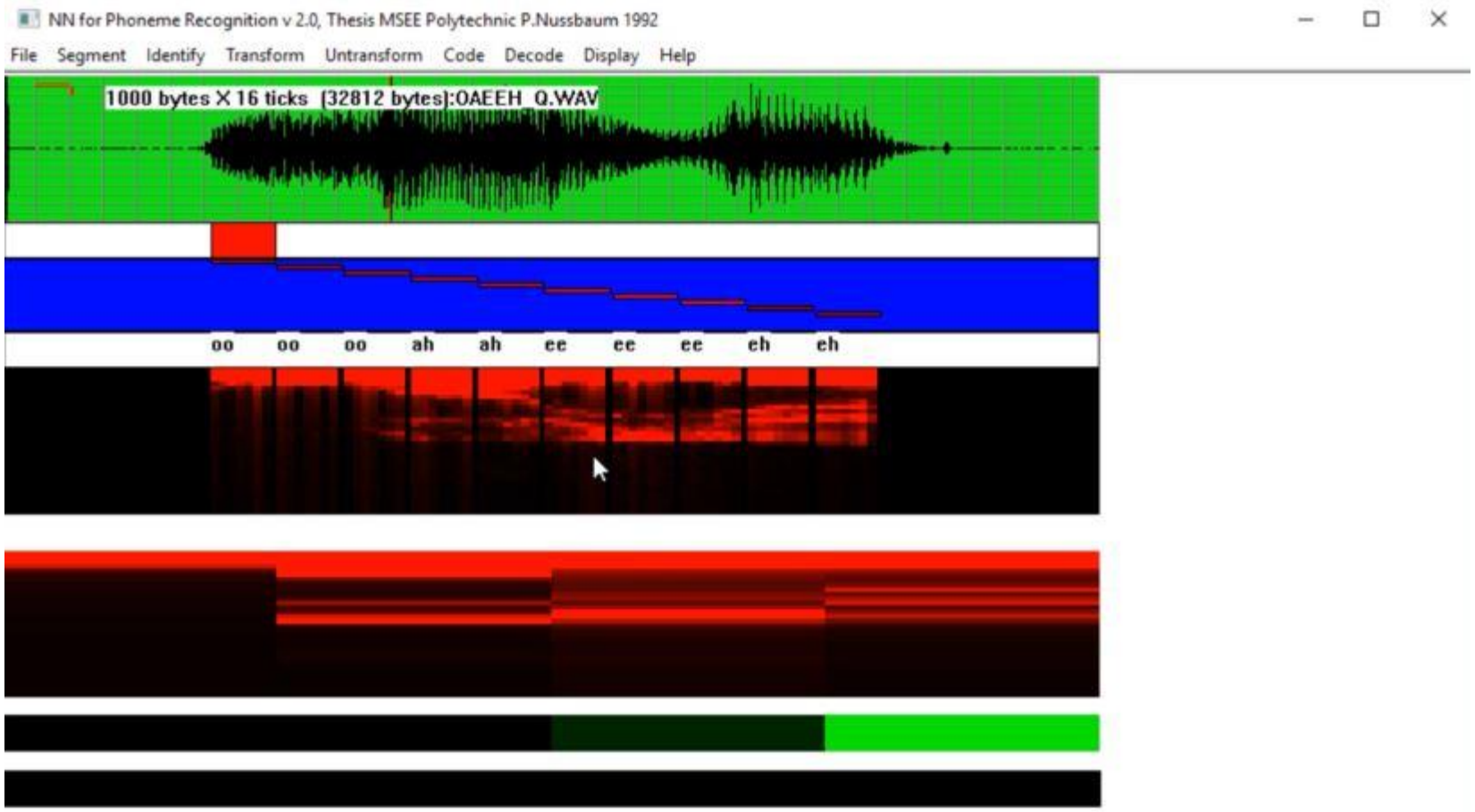
Notice that now, in addition to the Configuration and Training files, there is now Coding information (the trained AI robot's brain, using the personification analogy) which can be saved.



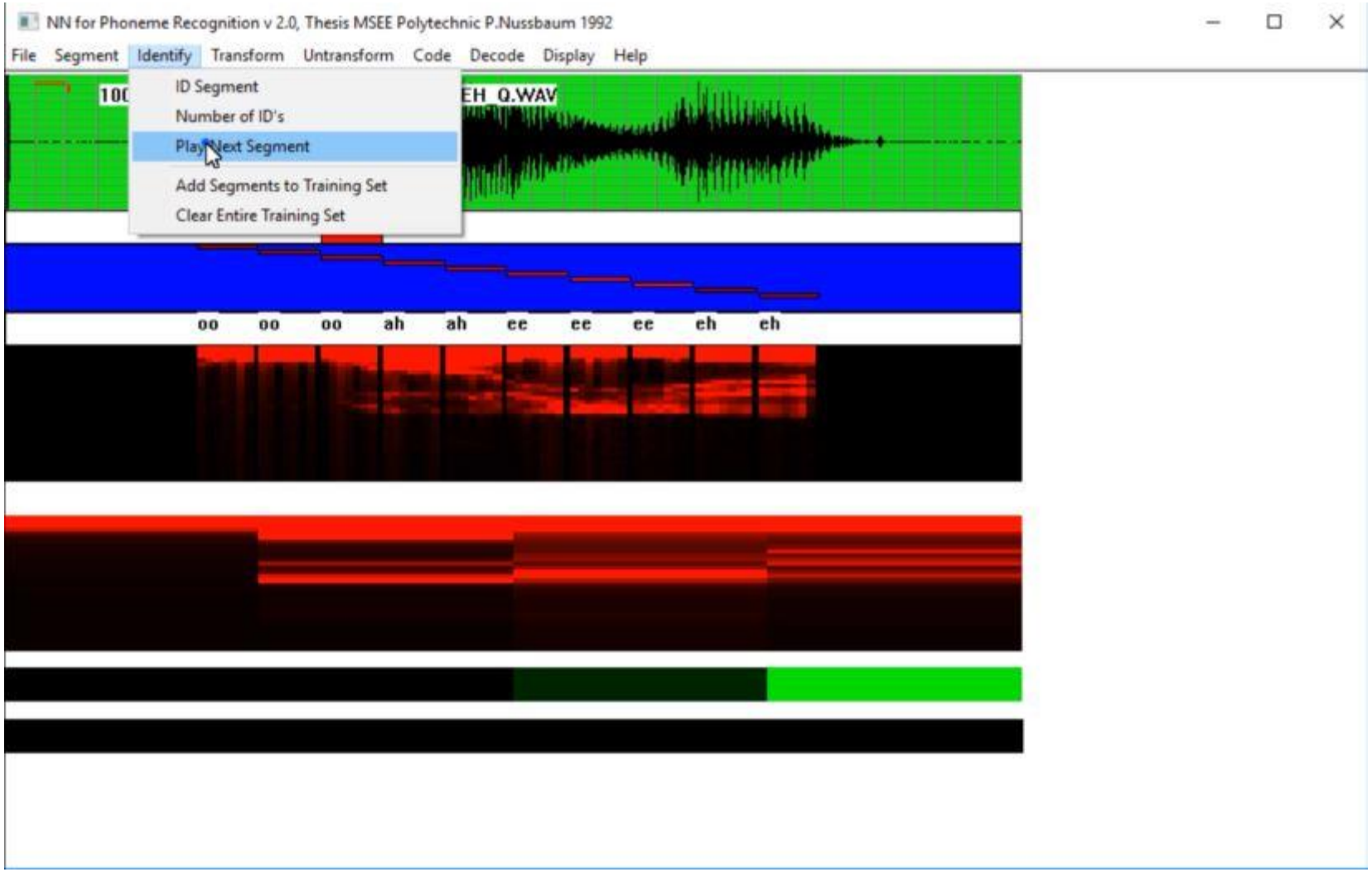
As per US Patent 5867816, INTEGRAT allows the human expert to observe how the trained AI robot behaves under conditions it was never trained for. In this case, we wish to load data which was not available in the training set and test how the robot will work in a fully automated mode to identify and make decisions about this new data.



Here the human expert chooses the OAHEEH_Q audio file. This contains all four phonemes spoken quickly, as if they were part of one word. In the case of phonemes, the harmonics created by the shape of the mouth, will no longer be stationary, but will be moving and changing continuously.



As can be seen from the above, the AI robot did a pretty good job of identifying at least the correct sequence order of the phonemes spoken. Notice how the vocal cord harmonics are continuously moving, gliding from one phoneme to the other as the mouth and tongue slide from one position to the next – without stopping for very long at all.



As can be seen from the green horizontal bar near the bottom, the last segment was identified as being mostly ID 4 “eh” but also in some small way resembled ID 3 the “ee” phoneme. Not shown here, but ss per US Patent 5864803, INTEGRAT allows the human expert assign multiple possible “correct” ID’s for segments which may be “ambiguous.”

This Concludes the INTEGRAT Demonstration and Instructions

I hope these methods and this software apparatus will help to improve the understanding by individuals and society of the capabilities and societal implications of intelligent systems.

Best Regards, Paul Alton Nussbaum, Ph.D.