2021-22 M2 DSAI

Artificial Evolution Mini-Project

Problem to be solved : Decomposing sums of sines

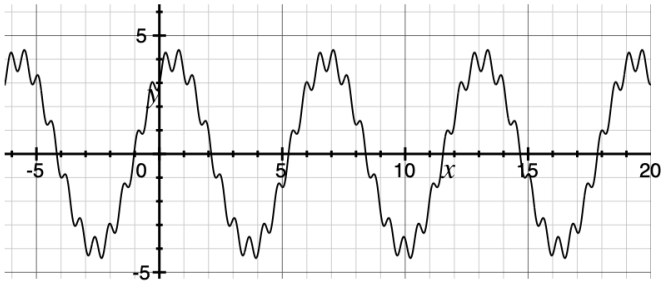
The standard way to decompose a sum of sines is to use a Fourier Transform. However, FT works as a whole and it is currently impossible to "help" it by, for instance, providing some pre-existing knowledge on the sum of sines. For instance, if one knows the frequency of a sine that composes the signal, it is impossible to provide the FT algorithm with this piece of knowledge to help it find the sine whose frequency is already known.

Conversely, it is also impossible to ask an FT to find one sine out of a sum of 3 sines, for instance. But this is what is needed when a signal is made of a large number of sines, but where scientists are only interested by 4 or 5 of them. Once more, either FT tries to find them all, but it cannot be asked to only find some of the sines that compose the signal.

All this can be done easily with an artificial evolution approach, where artificial evolution looks for different parameters characterizing one or more sines. If *a*, *f* and *p* denote respectively the amplitude, frequency and phase that characterize a sine, it is possible to look for the best values of *a*, *f* and *p* that will minimize:

$$errorSum = \sum (signalSample - a \cdot \sin(fx+p)) \qquad (1)$$

But by finding *a*, *f* and *p* such that (1) is minimized, what is being done? If the signal is the sum of 2 sines, such as:



$$f(x)=\tfrac{1}{2}\cdot\sin(11x-1)+4\cdot\sin(x+1) \qquad (2)$$

a) What values of *a*, *f*, and *p* will minimize $f(x) - a\cdot\sin(fx+p)$? Common sense would have it that "removing" the largest sine {4, 1, 1} from the sum of two sines will minimize the signal but is it really the case?
b) What if one wants to find one sine out of a sum of *n* sines (and not only 2 sines?)?
c) What if one wants to find *s* sines out of a sum of *n* sines?

What would an artificial evolution program such as sinusit find?

The object of this mini-project is to answer these fundamental questions.

Please try to do a scientific work. Show autonomy and reasoning in what you do.

Make a 10-20 pages report organised as a scientific paper, with your name ane affiliation, an abstract, an introduction, some sections (including a state of the art section) and a conclusion.

Don't forget to provide the .ez file with the correct data values so that the results presented in your report/paper are reproducible.