Summer Research Project
Video Based Mouse Seizure Detection

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Content

- A few concepts in image processing and computer vision:
  - Dot Product
  - Discrete Fourrier Transform

Background Concepts: Inner Product

Definition

The inner product is an operation obeying a set of properties that takes as input two vectors from a given space and produce a real number.

Application

An important application is to compute similarity between vectors.

$$A_b = \frac{||A \cdot B||}{||B||} \tag{1}$$

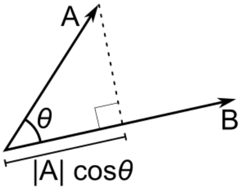

Figure : Dot product can be used to compute the component of A in the direction of B.

Background Concepts: Inner Product

A common space is the $\mathbb{R}^d$ and its usual dot product, but more interesting spaces also have inner product and different inner products can be defined for the same space, each one measuring a different kind of similarity.

- space: $\mathbb{R}^d$

$$\vec{v} \cdot \vec{w} = \sum_{i=1}^{d} v_i w_i \tag{2}$$

- space: continuous real functions on interval (a,b)

$$< u, v >= \int_a^b u \cdot v \tag{3}$$

Background Concepts: Inner Product

Application

Inner products are used to write a vector as a linear combination of a set of vectors that expand the space

An example in $\mathbb{R}^2$

The vector v = (1,2) can be written as:

$$(1,2) = 1.(1,0) + 2.(0,1) \tag{4}$$

Where (1,0) and (0,1) are vectors that expand $\mathbb{R}^2$. Note that the scalars can be found as:

$$(1,2) = [(1,2)\cdot(1,0)].(1,0) + [(1,2)\cdot(0,1)].(0,1) \tag{5}$$

Background Concepts: Inner Product

- In general, let the inner product be written as $< \vec{a}, \vec{b} >$ and let the set $\{\vec{v}_1, \ldots \vec{v}_d\}$ be the basis of a space of dimensionality d. A vector $\vec{x}$ can be written as:

$$\vec{x} = \sum_{i=1}^{d} < \vec{x}, \vec{v}_i > \vec{v}_i \tag{6}$$

- call the result $< \vec{x}, \vec{v}_i >= a_i$. We can represent x by the set of a_i's. That is, we can reconstruct $\vec{x}$ from its components a_i's

Background Concepts: Discrete Fourrier Transform

Motivation

We want a technique that allows us to study properties of sequences. We're given a sequence and we'll perform a set of operations that will give us coefficients, each informing us some property of the original sequence

- The sequence is an ordered and numbered set of values such as $\{\ldots, a_{-1}, a_0, a_1, \ldots\}$
- We're going to write any sequence as a linear combination of some other sequences.
- The basis of this space of sequences is a set of periodic complex exponentials e^{jwn}.
- In order to write a sequence of length M we need at least M complex exponentials. They are $e^{j\frac{2\pi}{M}kn}, k = 0, 1, \ldots, M-1$

Background Concepts: Discrete Fourrier Transform

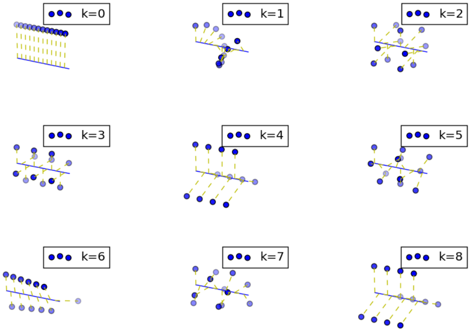

Figure : A few sequences of the form $y_n = exp(j\frac{2\pi}{M}kn)$ for M $= 12$

Background Concepts: Discrete Fourrier Transform

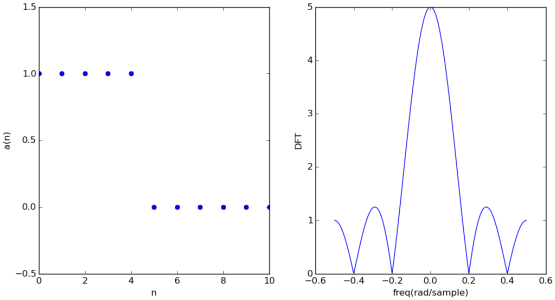

Figure : Example of 501 DFT of length 10 sequence

Background Concepts: Discrete Fourrier Transform

Applications

- When transmitting audio, we can compute the DFT components and then transmit it. The receiver then reconstruct the original signal by adding the right amount of components. More quality implies more DFT components.
- To every operation applied to the original signal, there is an equivalent operation applied to the signal's DFT. In some cases, it is easier and faster to convert the signal to its DFT, apply the operation on the frequency domain and then convert it back to time domain.
- Large convolutions are implemented this way by open cv.

Background Concepts: Discrete Fourrier Transform

Run FFT demo

Week Results: Line Wise Detector

- the neural network constructed was not able to learn the data. The accuracy I got on test data of around 60%
- The good news is that accuracy on training data was also very low. The good thing about it is that this suggests there is a bug somewhere, because neural networks should be able to, at least, overtfit the data.

Week Results: Changing the reference axis to compute optical flow

- Instead of computing the flow in the box, the flow is now computed in the points inside the box but in the global frame of the image.
- This reduced a lot the noise, but every now and then there is still some optical flow where nothing should be seen.
- Blurring the image only made it worse.
- Run demo

Week Results: Working on the labels

- At some point we'll have to look at the data we have
- I'm writing a program that takes as input a text file containing times of seizure and produces video containing it.
- The problem with this is that the data we have is split into several videos and some search is required.