Image restoration with inverse filtering

Lab 5, SDP

Table of contents

1 Objective 1

2 Theoretical notions 1

3 Practical application 2

3.1 Defining distortions . . . 2

Requirement 1 . . . 2

3.2 Distorting an image . . . 3

Requirement 2 . . . 3

Requirement 3 . . . 4

3.3 Restoring the image using inverse filtering . . . 4

Requirement 4 . . . 4

Requirement 5 . . . 5

Requirement 6 . . . 5

3.4 Final requirements . . . 5

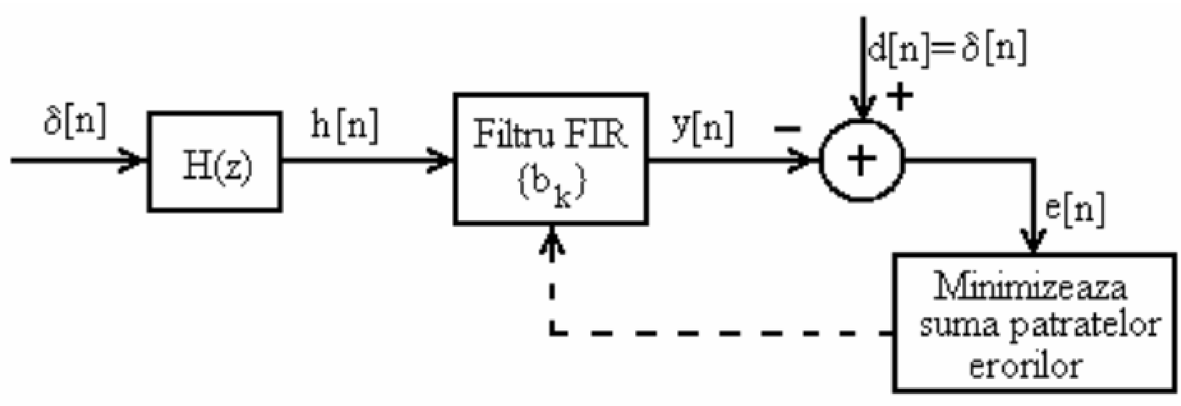
1 Objective

Using inverse FIR filters in an image processing application.

2 Theoretical notions

The inverse filter $H_I(z)$ of any filter $H(z)$ is the system that cancels the effect of $H(z)$ on a signal:

$$H_I\{H\{x[n]\}\} \approx x[n]$$



3 Practical application

We illustrate the use of the inverse filter through the following practical application.

3.1 Defining distortions

Let the four functions below define a series of distortions on an input signal/image:

`distort()`, `distort_more()`, `distort_noisy()`, `distort_delay()`

Requirement 1

Copy the functions below into Matlab files so that they can be used later.

```
function y = distort(x)
    L1 = 5;
    coef = [zeros(1,L1) 1.1.^[0:-1:-L1]];
    coef = coef / norm(coef,1);
    coef  = fliplr(coef);  % filter2 expects kernel, not impulse response, it doesn't flip
    coef;
    y = filter2(coef, x, 'same');
end
```

```
function y = distort_more(x)
    L1 = 10;
    coef = [zeros(1,L1) 1.1.^[0:-1:-L1]];
    coef = coef / norm(coef,1);
    coef  = fliplr(coef);  % filter2 expects kernel, not impulse response, it doesn't flip
    coef;
    y = filter2(coef, x, 'same');
end
```

```
function y = distort_noisy(x)
    L1 = 5;
    coef = [zeros(1,L1) 1.1.^[0:-1:-L1]];
    coef = coef / norm(coef,1);
    coef  = fliplr(coef);  % filter2 expects kernel, not impulse response, it doesn't flip
    coef;
    y = filter2(coef, x, 'same');

    y = y + 0.05*randn(size(y));
end
```

```
function y = distort_delay(x)
    Delay = 10;
    L1 = 5;
    coef = [zeros(1,L1+Delay) 1.1.^[0:-1:-L1]];
    coef = coef / norm(coef,1);
    coef  = fliplr(coef);  % filter2 expects kernel, not impulse response, it doesn't flip
    coef;
    y = filter2(coef, x, 'same');
end
```

3.2 Distorting an image

Requirement 2

Load the image `lena512.bmp`, convert it to type double, convert it to grayscale, and display it.

Use the following Matlab functions:

- `imread()`
- `double()`, followed by division by 255
- `im2gray()`
- `imshow()`

```
I1 = ...   % original image
I2 = ...   % after preprocessing
...
```

Requirement 3

Distort the image by calling the distortion function `distort()` on the image, and display the result.

What does the distorted image look like? What type of distortion is this?

```
I3 = ...
imshow(I3)
```

3.3 Restoring the image using inverse filtering

Steps:

1. Obtain the impulse response by calling the function on a unit impulse signal
2. Calculate the inverse FIR filter using the function from the previous lab
3. Filter each line of the distorted image with the inverse filter (1-D filtering) and store the results in a new image.

   For filtering, use one of the following two functions:

   - function `filter2(h, I3)`
   - function `filter(h, 1, I3(i,:))` on each line `i` of the image

4. Display the result

Requirement 4

Find and display the impulse response of the distortion `distort()`

```
h = ...
```

Requirement 5

Calculate the inverse filter with the function `InverseFIR()` from previous lab, display the coefficients and the impulse response.

What is $H(z) = ?$

```
b =

% Make b horizontal
b = b'

stem(b)
```

Requirement 6

Filter each line of the distorted image with the found filter, store the results, and display the final image.

```
...

imshow(Irec)
```

3.4 Final requirements

1. Repeat with other images (`bugs.jpg`, `barbara.png`)
2. Repeat with the other `distort_*()` functions. When are the results worse?