GETA
Selected Topics of Mobile Communications

Viet-Anh LE
68713L

Problems of the courses

(1) Consider mechanisms of spatial diversity, time diversity and frequency diversity. Give three examples to explain each of them respectively.

- Spatial diversity: the signal is transmitted over several different propagation paths, used for example in space–time coding.
- Time diversity: multiple versions of the same signal are transmitted at different time instants, used for example in interleaving.
- Frequency diversity: the signal is transmitted using several frequency channels or spread over a wide spectrum that is affected by frequency-selective fading, used for example in OFDM .

(3) How can one expect for the performance of RAKE receiver when the number of multipath is increased.

When the number of multipath is increasing, we can expect improvement in performance for the RAKE receiver since the RAKE receiver is design to take advantage of the diversity in the received signal.

(5) Discribe how to use the pilots of CDMA in the beamforming of smart antenna.

 In CDMA system for smart antenna, the pilot code is used as the reference signals for calculating beamforming weights.

Assignment for GETA course
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(1) Consider mechanisms of spatial diversity, time diversity and frequency diversity. Give three examples to explain each of themrepectively.

Answer:
CDMA2000 uses both spatial diversity and frequency diversity as it uses more than one frequency and more than one Tx antennas;
MIMO used both spatial diversity and time diverisity as it used more than one antenna and different time samples.
RAKE receiver is an example of time diversity since it uses different time samples.

(2) What is the bandwith efficiency of a CDMA, when we consider only the following parameters:
Spreading factor is N
Number of active code channel is K

Answer:
When the spreading factor is N, the bandwidth efficiency become $1/N$ compared to using the raw chip.
When the number of active code change is K, the efficiency becomes to K/N since K code channel is sharing the same bandwith.
Hence the bandwith is K/N.

(6) Explain why it is difficult to use CDMA in broadband communication systems.

Answer:
The capacity of CDMA system is limited by selft interference, for wideband communication, the interference will be much stronger which leads to the biggest problem for using CDMA in broadband communication systems like 4G.

Selected Topics of Mobile Communication
Assignment solutions

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Question 3. How can one expect for the performance of RAKE receiver when the number of multipath is increased?

As the number of multipaths increases, the performance of the RAKE receiver is improved. However, due to several factors (eg. design complexity, problems in channel estimation), the number of multipath components is usually limited to some level, where the performance is good enough. It should also be noted that as the number of multipath components is increased, the performance gain achieved by adding these new multipath components is continually decreased.

**Question 5. Describe how to use the pilots of CDMA in the beamforming of smart antenna**

In a smart antenna we have an antenna array and each of the array components are weighted in some manner to obtain directivity. The weights are chosen in such a way that the Signal-to-Interference Ratio is maximized which is equivalent to minimizing the mean square error between the reference signal and the received signal. In a CDMA system, these weights can be determined by using the pilot signals as reference signals because they are known.

Question 6. Explain why is it difficult to use CDMA in broadbad communication systems

In broadband communication systems, frequency selective fading is normal. This means that if CDMA is used, the spreading codes are no longer orthogonal. Without this orthogonality, there is interference between users as well as intersymbol interference, which both degrade the performance of the system significantly.

Question 7. Calculate the IMF1 and the IMF2 of HHT method for the given signals

In the HHT method, the maximum and minimum envelopes of the input signal are estimated and IMF is the average of these envelopes at each time instant. We were asked to calculate the first two components given by the HHT method for the signals $x_1 = Acos(w_0 t)$ and $x_2 = Acos(w_0 t) + Acos(2w_0 t)$. The signal x_1 and its IMFs 1 and 2 are depicted in Fig. 1(a). As we can see, the first IMF component is practically zero, because the sinusoid has only one component. The reason for the slight ripple at the sides of the figure is the implementation.

(a)

(b)
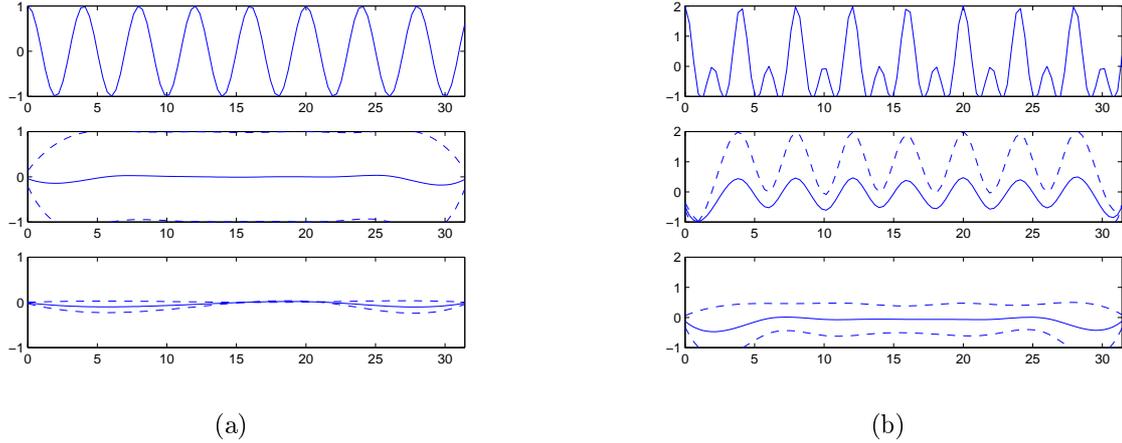
Figure 1 – (a) The signal $x_1 = Acos(w_0t)$ (with $A = 1, w_0 = \frac{\pi}{2}$) and its two first IMF components (b) The signal $x_2 = Acos(w_0t) + Acos(2w_0t)$ (with $A = 1$, $w_0 = \frac{\pi}{2}$) and its two first IMF components

The analytical solution would be

$$x_1 = Acos(w_0t)$$
$$IMF1 = 0$$
$$IMF2 = 0$$

For the second signal, the original version and the IMF components are presented in Fig. 1(b). From the figures we can see that the signal IMF1 is a sinusoid and again, IMF2 is practically zero. The reason for this is that the signal x_2 is a sum of two sinusoids. In analytical form

$$x_2 = Acos(w_0t) + Acos(2w_0t)$$
$$IMF1 = 0.5Acos(w_0t)$$
$$IMF2 = 0$$

The code for the implementation and for the figures is given below.

```
% hht testing

close all;

w0 = pi/2;
A = 12;
t = linspace(0,10*pi,100);

x1 = A*cos(w0*t);

[imf11,s11,s12] = HHTransform(x1);
[imf12,s21,s22] = HHTransform(imf11);

figure; subplot(3,1,1);
plot(t,x1); axis([0 Inf -A A]);
subplot(3,1,2);plot(t,imf11);
hold on;plot(t,s11,'--');
plot(t,s12,'--'); hold off;
axis([0 Inf -A A]); subplot(3,1,3);
plot(t,imf12); hold on;
plot(t,s21,'--'); plot(t,s22,'--');
```

```
hold off; axis ([0 Inf -A A ]);

x2 = A*cos(w0*t) + A*cos(2*w0*t);

[imf11,s11,s12] = HHTransform(x2);
[imf12,s21,s22] = HHTransform(imf11);

figure; subplot(3,1,1);
plot(t,x2); axis([0 Inf -A 2*A]);
subplot(3,1,2); plot(t,imf11);
hold on; plot(t,s11,'--');
plot(t,s12,'--'); hold off;
axis([0 Inf -A 2*A]); subplot(3,1,3);
plot(t,imf12); hold on;
plot(t,s21,'--'); plot(t,s22,'--');
hold off; axis([0 Inf -A 2*A]);


function [imf,s_max,s_min] = HHTransform(x)

[maximums,locs_max] = findpeaks(x);
[minimums,locs_min] = findpeaks(-x);
N = length(x);

s_max = spline([0 locs_max N+1],[0 maximums 0],1:N);
s_min = spline([0 locs_min N+1],[0 -minimums 0],1:N);

imf = (s_max+s_min)./2;

end
```