Optimization Theory for Communications
Final Project

Due: 2022/06/19

1. Nutrition Problem

(a) According to the above table, please give the food plan with the less price.

如圖及結果所示，一天中吃下這些數量的水果，所需的花費最少且能補充所需的營養。

```
Status: Solved
Optimal value (cvx_optval): +93.1737

>> litchi

litchi =

   1.4781e-08
```

```
>> banana

banana =

    4.0719
```

```
>> pineapple

pineapple =

   10.7784
```

(b)

robust linear programming

結果如圖，由此得知在最壞情況下用最少的錢得到的食物計畫。

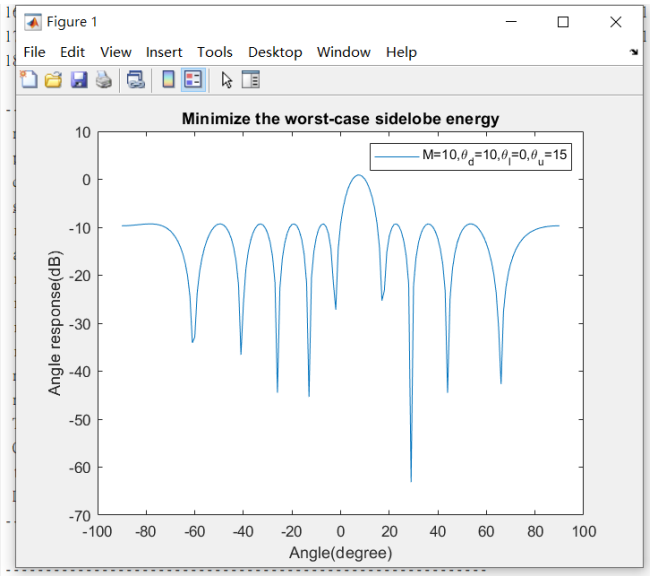
```
Status: Solved
Optimal value (cvx_optval): +105.367

litchi =

   4.7560e-09
```

```
banana =

    4.0719
```

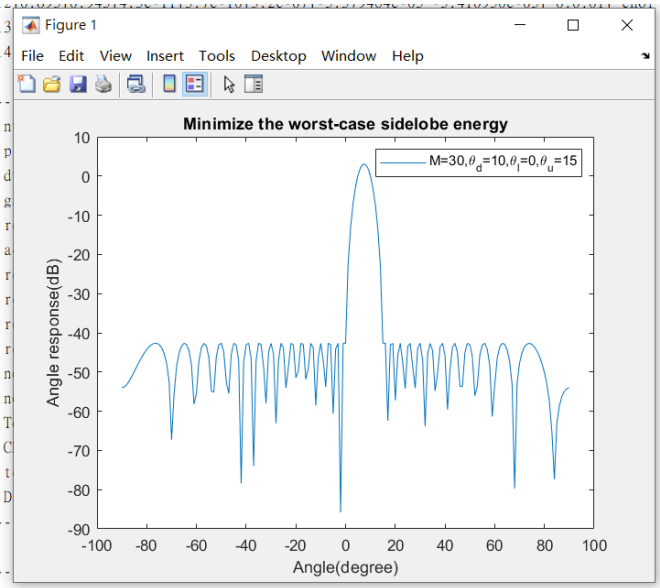
```
pineapple =

   10.7784
```

2. Worst-case Beamforming Design Problem:

Compare the results with the number of antennas $M = 10$ and $M = 30$ with $\theta_d = 10°$.




```
Status: Solved
Optimal value (cvx_optval): +0.117622
```

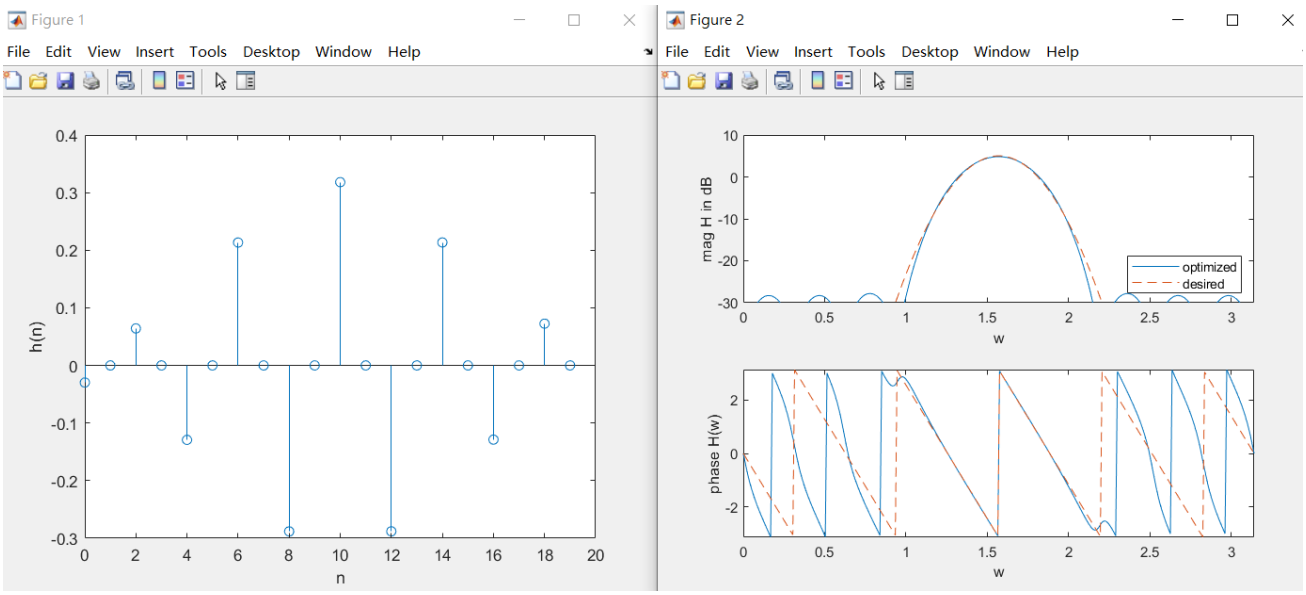



```
Status: Solved
Optimal value (cvx_optval): +5.40542e-05
```

由上面兩張圖可知，兩側干擾都平均掉了，故符合題目要求。而觀察天線數量(10、30)對於 minimize the worst-case sidelobe energy 的影響，發現天線數量愈多，其兩側干擾的 angle response 越低且越平均。

3. FIR Design Problem:

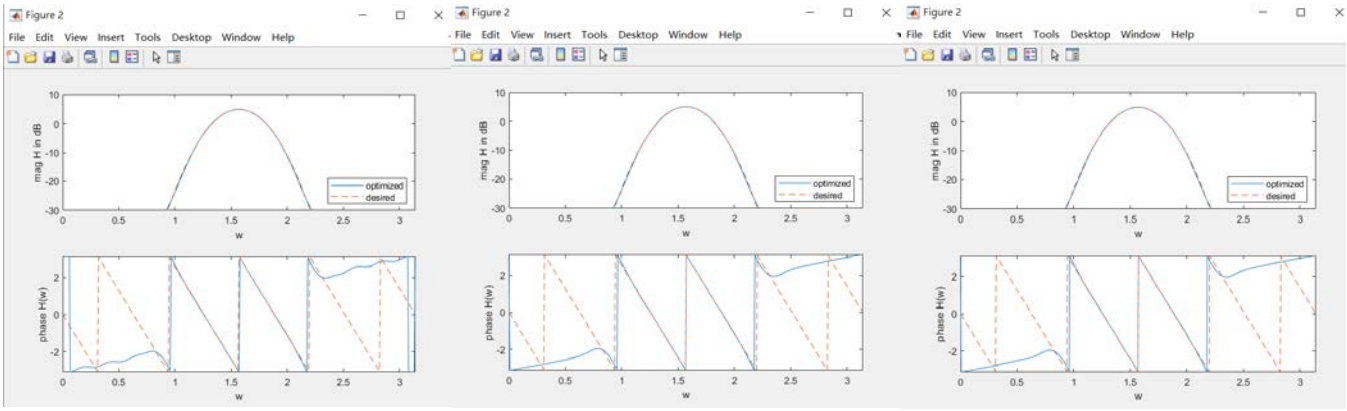
(a) When $L = 20$, please show the impulse, magnitude, phase response of the designed FIR filter and compare with the specification.



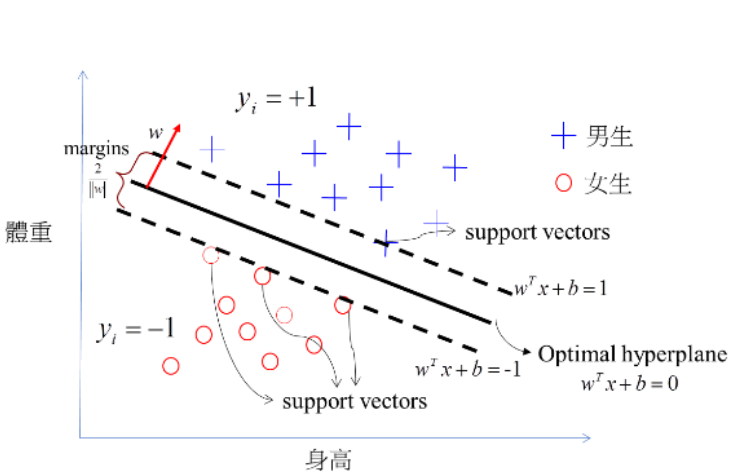
由圖可知，當 | H(w) – Hspec(w) |最大時，能找到最小的 Optimal value。

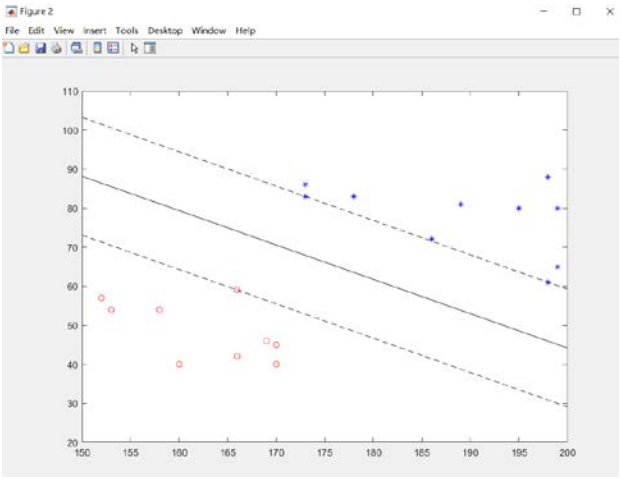
(b) As L increases, what do you observe ?

下圖分別是 L=25、L=30、L=40，可以看出當 L 越大，找到的曲線會越逼近最佳解的曲線。



4. Support Vector Machine Design Problem





SVM 是一種監督式的機器學習方法，用統計風險最小化的原則來估計一個分類 hyperplane，觀念簡單來說就是找到一個 decision boundary，讓兩類之間的 margins 最大化，使其可以完美區隔開來。題目是分類男生和女生兩類，特徵資料只有「身高」和「體重」。而由上圖可知，實線部分為最佳解(男女的邊界距離最大)，且兩側虛線與實線的距離是相等的。

5. Transmit Power Control Problem

(a) Consider the worst case design, and apply geometric programming (GP) to find the total required transmit power and the SINR at each user. (Please refer to lecture 4, page 10.)
(Note that please rewrite the associated GP problem to a convex form.)

```
Status: Solved
Optimal value (cvx_optval): +0.04506

p(1) = 7.355000
 p(2) = 10.000000
 p(3) = 1.214160
```

如圖，由 GP 求出 total required transmit power 為最佳解，而各使用者的 SINR 分別為 P(1)、P(2)、P(3)。

(b) Minimize the total transmit power, subject to all the users' SINRs $\gamma_0 \geq 10\ dB$. Please find the total required transmit power and the SINR at each user. (Please refer to lecture 3, page 22.)

```
Status: Solved
Optimal value (cvx_optval): +0.697727

p(1) = 0.276107
 p(2) = 0.306891
 p(3) = 0.114729
```

使所有使用者的 SINR 符合條件，如圖所示，total required transmit power 為最佳解，而各使用者的 SINR 分別為 P(1)、P(2)、P(3)。

(c) The worst design problem in (a) is actually a quasi-convex problem. Please apply the bisection method to find the optimal total required transmit power and the SINR at each user, and give comments on the results obtained from the GP and the bisection method.

```
Status: Solved
Optimal value (cvx_optval): +0.04506

p(1) = 7.355000
 p(2) = 10.000000
 p(3) = 1.214160
```

GP 並非凸優化問題，它是由 log 轉換成凸函數，再去解最佳化問題 。 而 bisection method 求一函式根的方法是先找一區間[a,b]，使函數值異號(代表根必在 a、b 之間)，再找 a、b 中點，中點之函數值與 a 點函數值同號取 [m, b] 為新的區間, 否則取 [a, m]，重複步驟到找到最佳解。
最後如圖所示，bisection method 及 GP 求出的結果相同，total required transmit power 為最佳解，而各使用者的 SINR 分別為 P(1)、P(2)、P(3)。

<Notice>

- The report and simulation codes are uploaded to ee-class
- File: ID_name.rar (e.g., 965403001_王小明.rar)