NeuroPass: Secure Neural Password using EEG sensor

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Introduction and Motivation

What is an EEG signal?

- Electroencephalogram
- First demonstrated by Vladimir Pravdich-Neminsky in 1912 on a household canine
- Voltage measurement of ionic current flows within neurons of the brain
- Ensemble of neural oscillations

Why should you care?

- Little concrete analysis of such measurable electronic potentials
- Computational framework needed to interpret signals since single neurons cannot be held responsible
- Can help understand how the brain's signaling system works

Information coding on neural channels

Brain's signaling system

- The brain is able to communicate with many muscles and cells throughout body over a network
- Signaling system, measured via electronic potential, is a key metric
- EEG in particular can help brain mapping

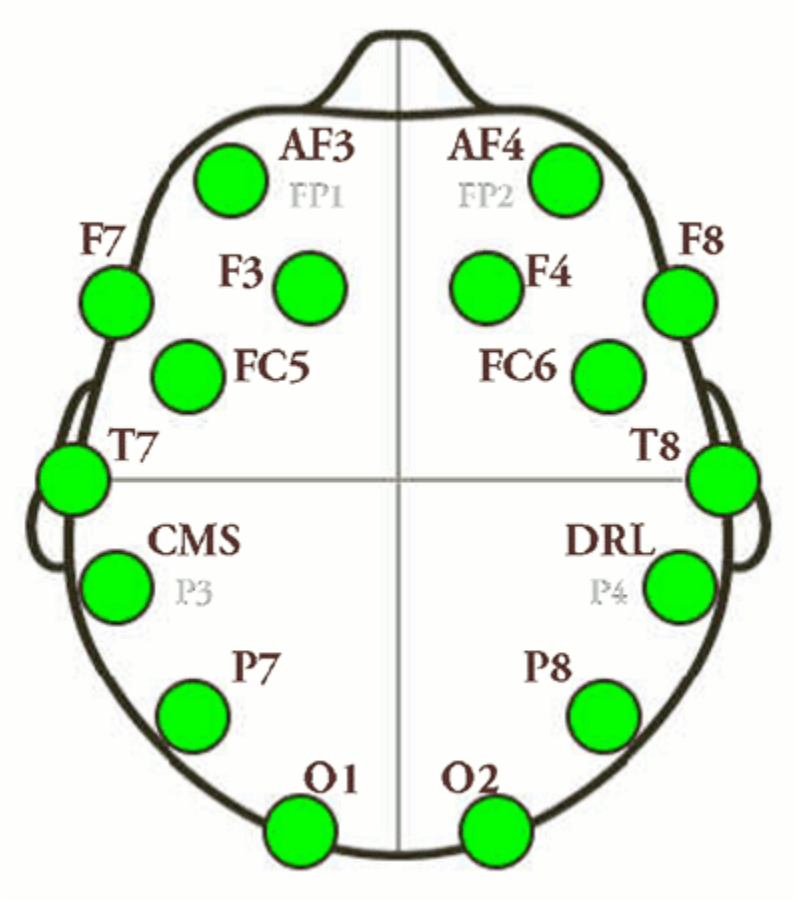
What are we proposing?

- Examine extent of coded neural information
- *Propose:* Detect salient, or even non-obvious higher-dimensional, signal features
- Can both understand how brain's signaling system works and create something useful/futuristic!

NeuroPass: EEG password

- Our project's goal is to generate a stream of coded information from neural (EEG) signals
- Information can be decoded from 14 available channels
- Can re-encoded in the form of a password

- Emotiv EEG headset



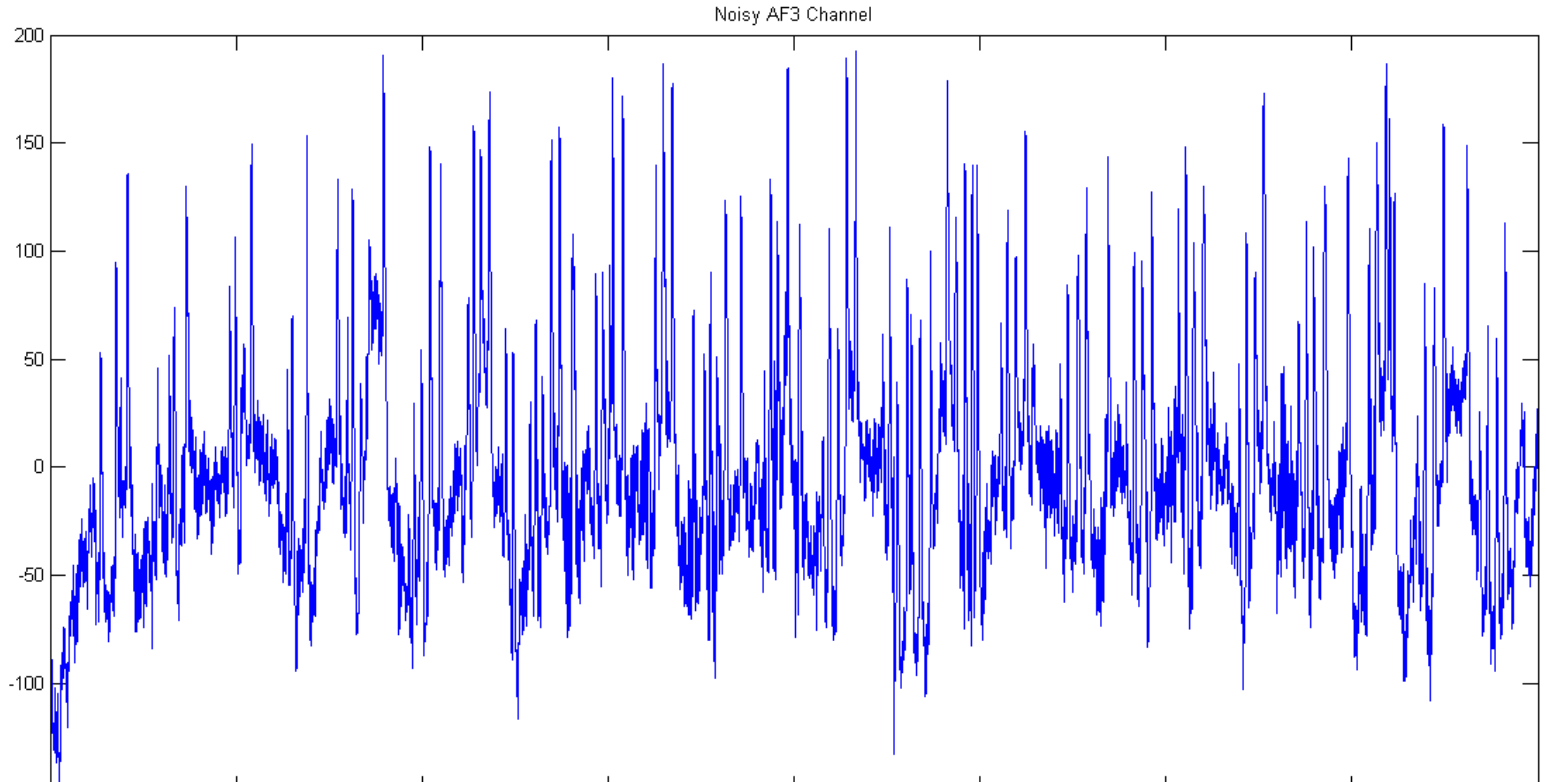
Detection on a Noisy Channel

- **Challenge:** analyzing arbitrary biological data to make dependable decisions from fundamentally noisy information

- So what do one of these things look like?

Detection on a Noisy Channel

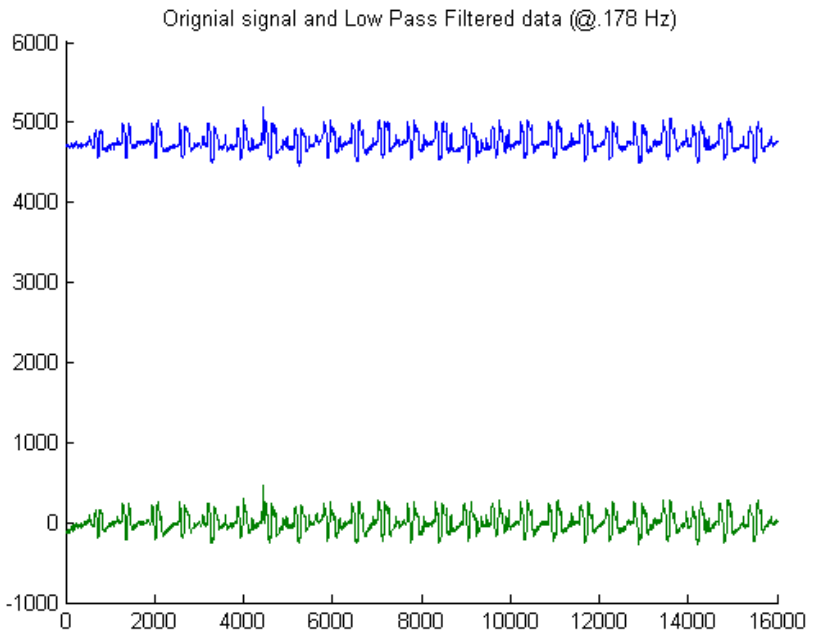
- **Challenge:** analyzing arbitrary biological data to make dependable decisions from fundamentally noisy information

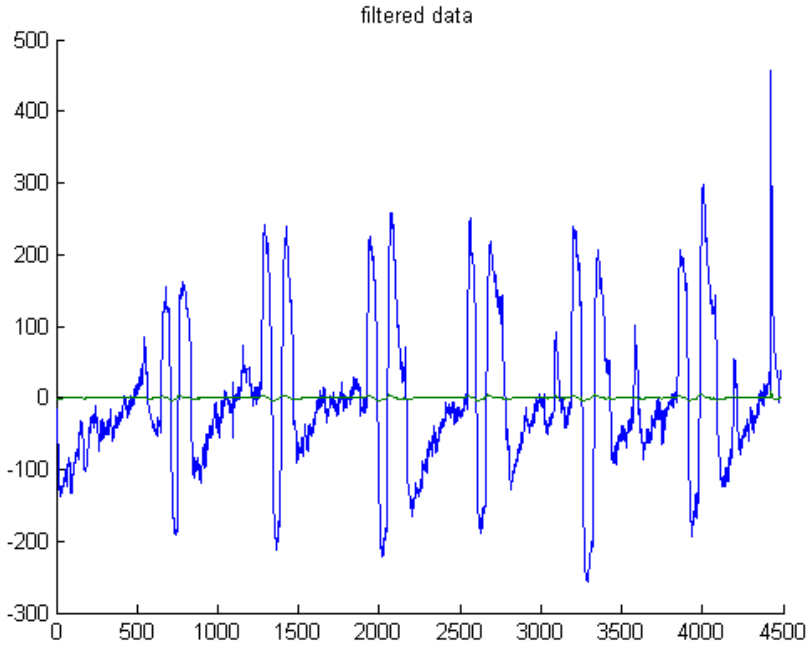


Noisy detection methods developed

- **Figure 2a:**
  - **DC offset removal**
- **Figure 2b:**
  - **Digital filtering**

- Figure 3: Local Minima + Threshold
- Figure 4: Masking



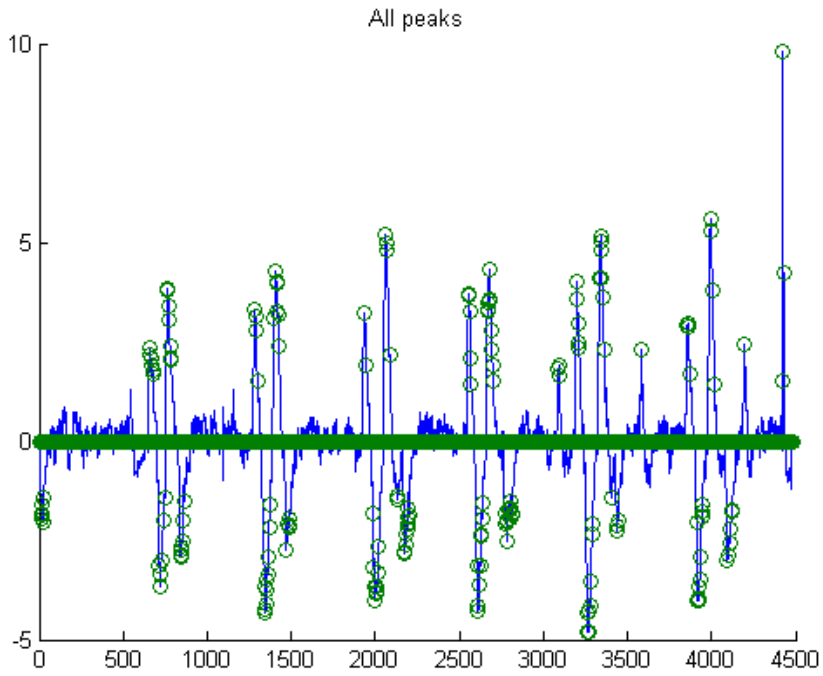


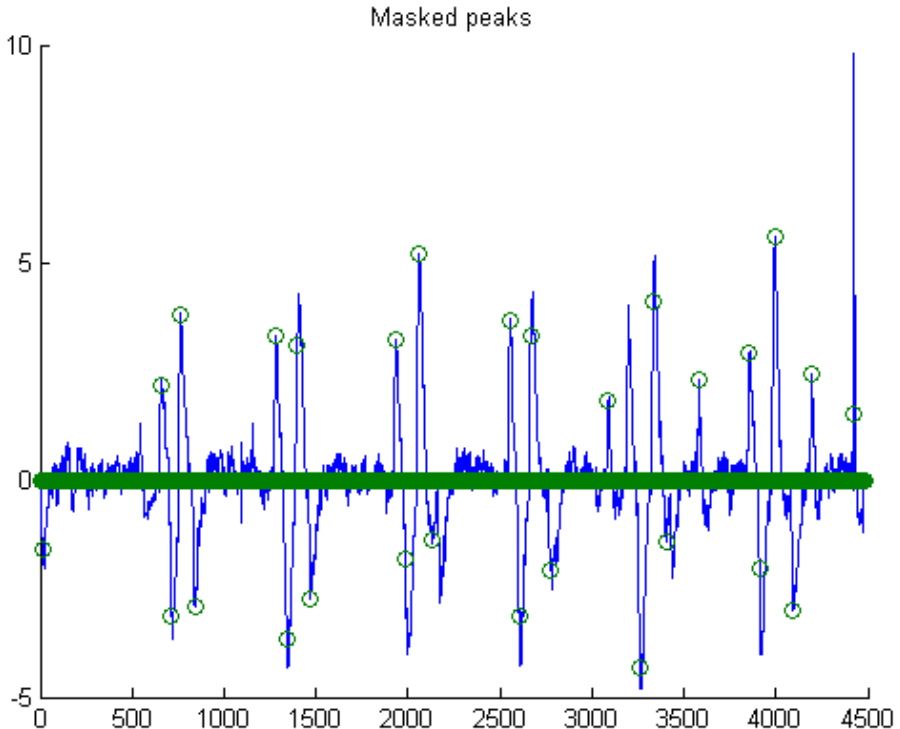
Noisy detection methods developed

- Figure 2a: DC offset removal
- Figure 2b: Digital filtering

- **Figure 3:**
  - **Local Max/Min & Threshold**
- **Figure 4:**
  - **Masking**

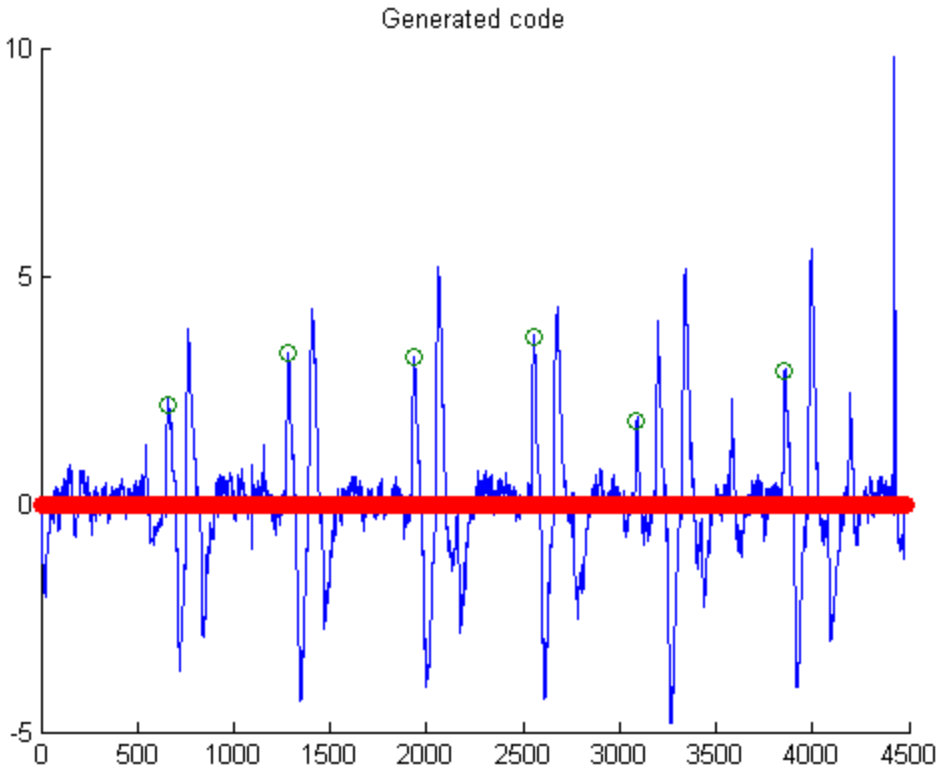
$$t(x) = \operatorname{sgn}\left(\sum_{i=1}^{n} w_i x_i - \theta\right).$$





Code Generation

- **Figure 5:**
  - **Generated Code**



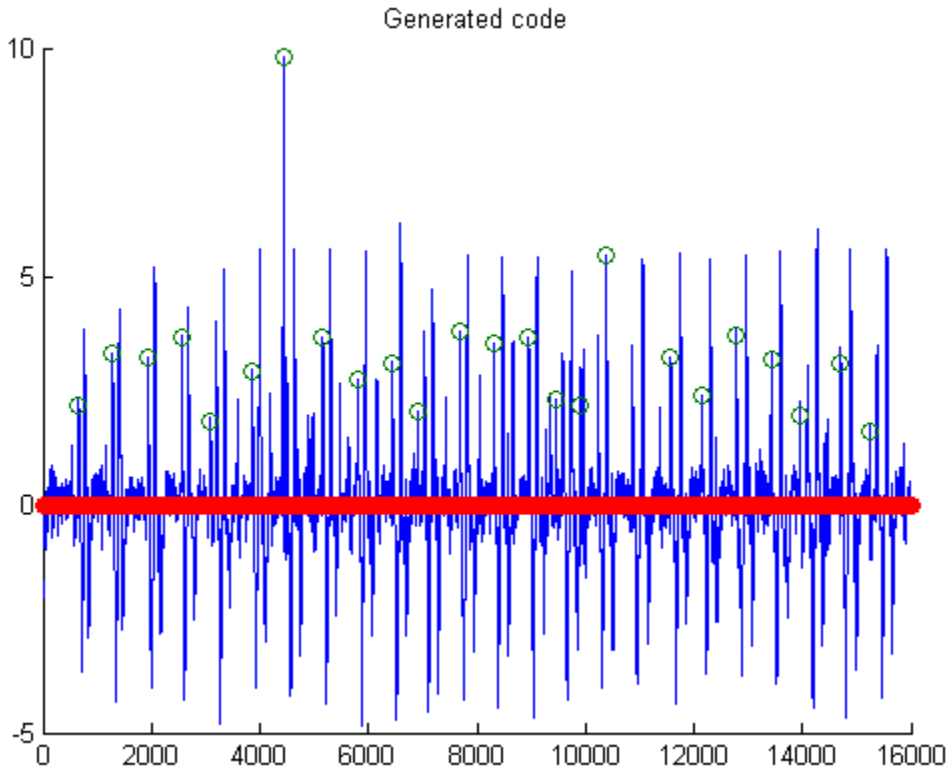
>> code

code =

656	2
1282	2
1933	2
2552	2
3089	2
3854	2

Code Generation

- **Figure 6:**
  - **Generated Code : Feature detection**




```
>> code
         656     2
        1282     2
        1933     2
        2552     2
        3089     2
        3854     2
        4425     2
        5160     2
        5797     2
        6438     2
        6916     2
        7679     2
        8308     2
        8957     2
        9468     2
        9912     2
       10382     2
       11576     2
       12137     2
       12783     2
       13425     2
       13952     2
       14703     2
       15234     2
```

Challenge 1: Data Uniformity

- Data collection is not uniform from run-to-run due to EEG sensor placements

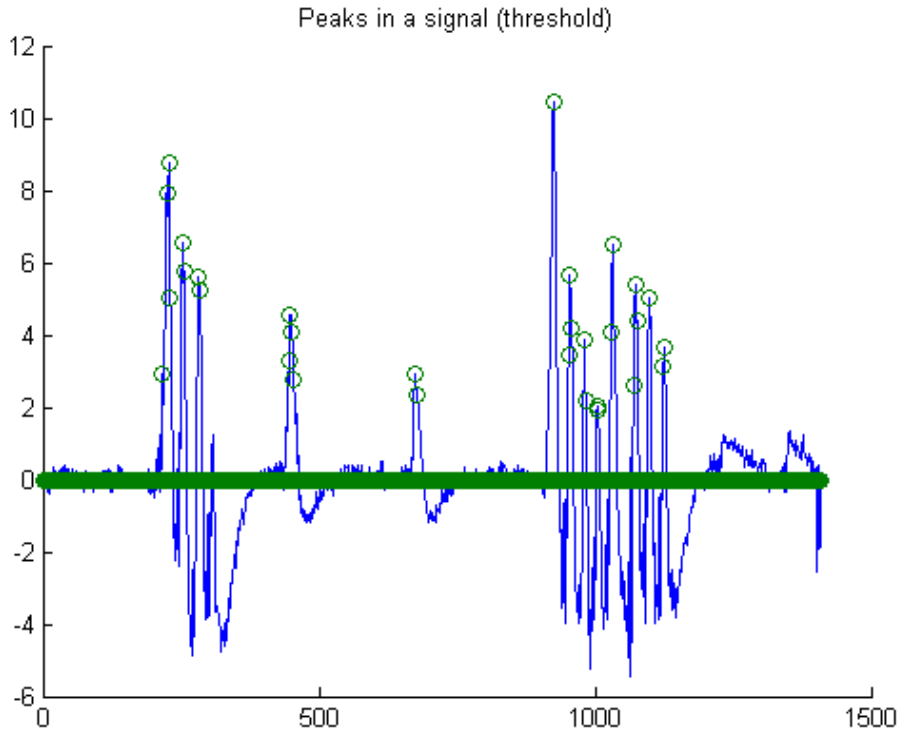
- Channel sources change between runs making data-uniformity very challenging!

- Therefore, data interpretation might change over time!

- Codings developed:
  - Feature detection
    - (blinks, clenches, eye-rolling)
  - Pulse Width Modulation
    - PWM of peaks

- Developed in Matlab (no special functions) and C!

Challenge 1: Data Uniformity



- Codings developed:
  - Feature detection
    - (blinks, clenches, eye-rolling)
  - **Pulse Width Modulation**
    - **PWM of peaks**
- Developed in Matlab (no special functions) and C!

>> code

3323

same output in C!

Challenge 2:

Serious corrosion of contact affects signal tremendously:

Solution: chemistry

Before and After treatment

- Copper gets corroded easily

Challenge 3: DSK Memory

DSK has 32 k of internal data memory

4 bytes needed to store a float

14 channels of data

128 samples per second

30 seconds of data

215040 bytes needed!

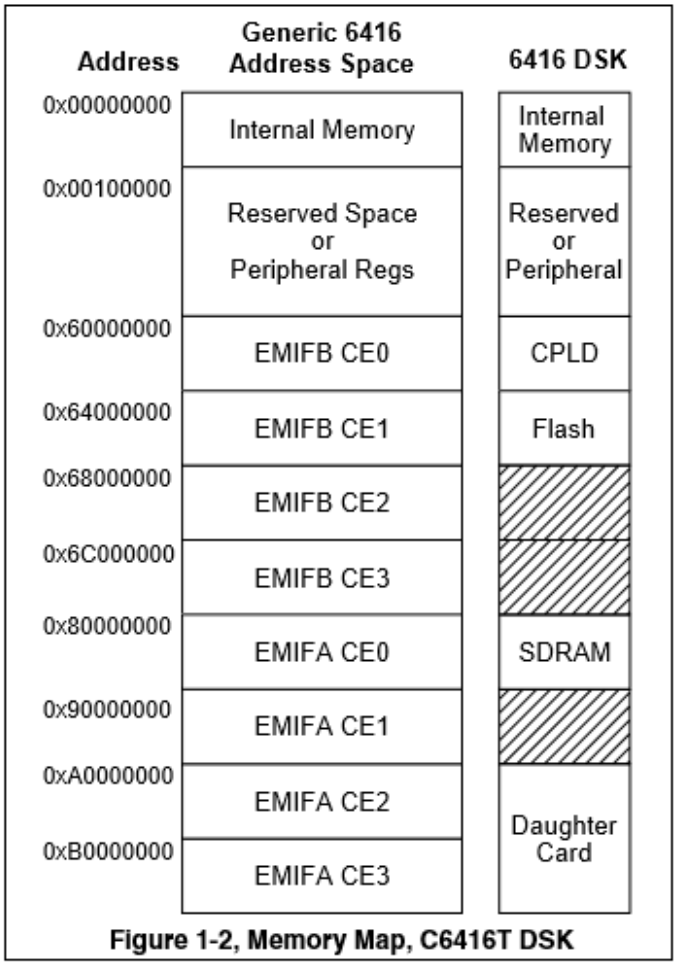
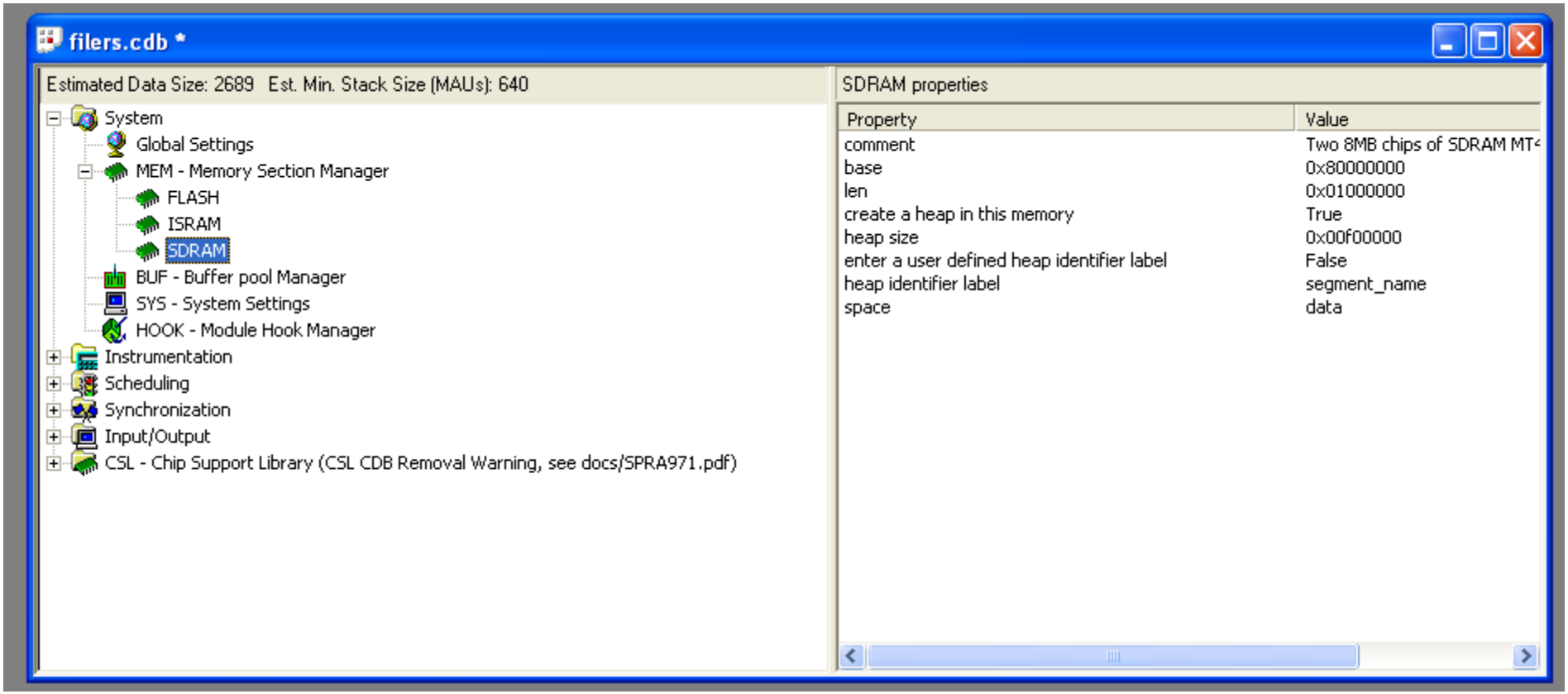


Figure 1-2, Memory Map, C6416T DSK


filers.cdb *
Estimated Data Size: 2689 Est. Min. Stack Size (MAUs): 640
System
Global Settings
MEM - Memory Section Manager
FLASH
ISRAM
SDRAM
BUF - Buffer pool Manager
SYS - System Settings
HOOK - Module Hook Manager
Instrumentation
Scheduling
Synchronization
Input/Output
CSL - Chip Support Library (CSL CDB Removal Warning, see docs/SPRA971.pdf)
SDRAM properties
Property
Value
comment
Two 8MB chips of SDRAM MT
base
0x80000000
len
0x01000000
create a heap in this memory
True
heap size
0x00f00000
enter a user defined heap identifier label
False
heap identifier label
segment_name
space
data

Thank You!