Introduction to Biomedical Engineering
Lab observation I, 19 May 2009

Questions to be addressed

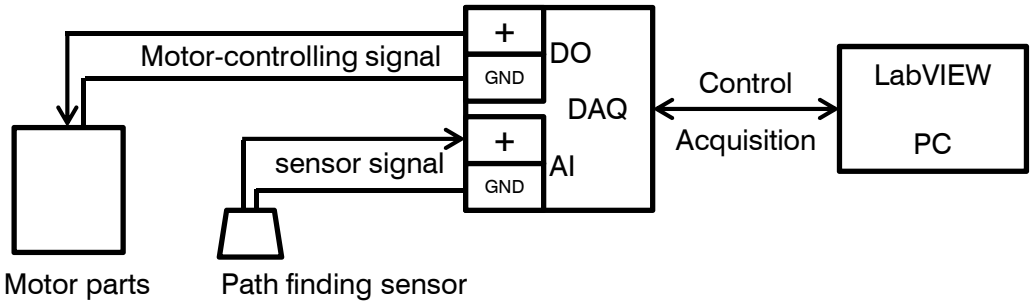
I. LabVIEW-based Experiment System

1. What are advantages and disadvantages of LabVIEW against conventional tools such as VC++ and MATLAB?

Advantages: easy connection to control hardware and to acquire data, GUI-based programming, clearly-illustrated logic flow, and so on.

Disadvantages: low performance compared to C/C++-based software.

2. Briefly draw a schematic diagram of hardware connection to implement a simple path-finding micromouse.

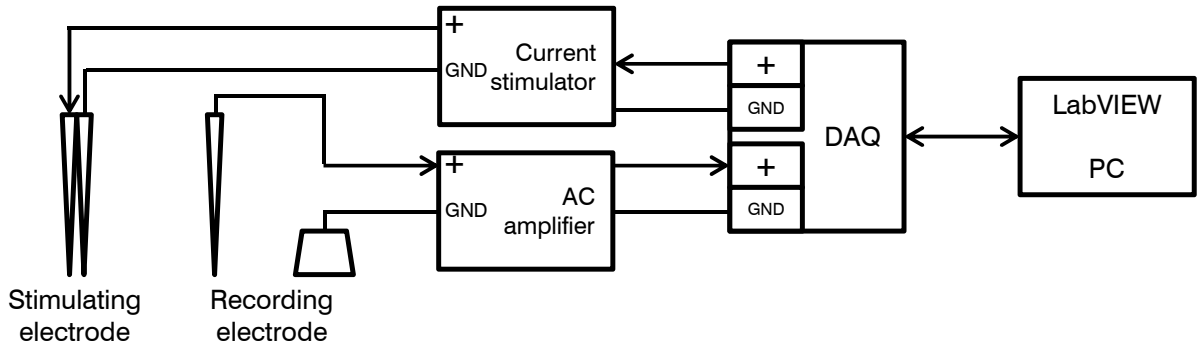


(Another connection will be possible. The above diagram is just one example.)

3. Try to build, if available, a LabVIEW-based virtual oscilloscope including digital filters, and capture the screen of its front panel and block diagram.

(Various UI design and algorithm will be possible.)

4. Draw a schematic diagram of the system for electrical stimulation and recording.



5. Suggest a real-time block-averaging algorithm that you think is the most efficient in memory usage.

Consider that we have an average data from n recordings (V_{avg}) and the (n+1)th recording is just acquired (V_{n+1}). Then, we can update V_{avg} with a new average of (n+1) recordings in real-time as follows:

$$V_{avg}^{(n+1)} = \frac{1}{n+1}\left\{V_{n+1} + n\, V_{avg}^{(n)}\right\}$$

II. Local Field Potential (LFP) Recording in Brain Slices

1. Why is the concentric bipolar electrode useful in stimulating neural tissues while the Teflon-insulated wire is typically used in recording?

In order to stimulate specific neurons in a large tissue, we should generate an electric field (or current) which is very localized to <100 um. For this reason, cathode and anode of stimulating electrode should be located very close to each other. The concentric bipolar electrode meets this requirement.

2. What will happen to recording signals if you use a recording electrode of much larger/smaller conducting area than typically-used electrodes? Explain why using the concept of equivalent measurement volume and impedance.

When you use the recording electrode of much larger area, the measurement volume (the volume within which the electrode monitors an electrical change) is so large that you could not detect a

tiny and localized electrical change. If you use one of smaller area, the recorded signal will be contaminated by considerable noise because the impedance of electrode is so high.

3. What are the useful condition of signal filtering for electrical neural recording?

Filtering condition varies with the kind of neural activity to be recorded. For local field potentials in brain slices, the band-pass filtering of 10 to 10,000 Hz is typically used. Especially for excitatory post-synaptic potentials only, the band-pass filtering of 10 to 1,000 Hz can be used. The notch filter of 60 Hz is not necessarily used.

4. Search and study neurological functions of the hippocampus, and briefly summarize them.

(You can easily find answers from Wikipedia.)

Three main ideas of hippocampal function have dominated the literature: inhibition, memory, and space. The behavioral inhibition theory derived much of its justification from two observations: first, that animals with hippocampal damage tend to be hyperactive; second, that animals with hippocampal damage often have difficulty learning to inhibit responses that they have previously been taught.

The second major line of thought relates the hippocampus to memory. The unexpected outcome of the surgery was severe anterograde and partial retrograde amnesia: H.M. was unable to form new episodic memories after his surgery and could not remember any events that occurred just before his surgery, but retained memories for things that happened years earlier, such as his childhood. There is now almost universal agreement that the hippocampus plays some sort of important role in memory; however, the precise nature of this role remains widely debated.

The third important theory of hippocampal function relates the hippocampus to space. As with the memory theory, there is now almost universal agreement that spatial coding plays an important role in hippocampal function, but the details are widely debated.

5. How is the neurophysiological mechanism underlying the population spike different from that of the excitatory postsynaptic potential (EPSP)?

The population spike (PS) dominantly originates from action potentials propagating through axons, while the EPSP comes from post-synaptic currents occurring when neurotransmitters are released

from the pre-synaptic site and are bound to receptors of the post-synaptic site. Since the EPSP is mediated by chemical signaling, it lags behind the PS.

6. Imagine a novel method by which you could detect neural activity in brain tissues.

Recently, many research groups are trying to develop a novel method for detecting neural activity. Beyond the electrical detection, we can use a voltage-sensitive dye to image neural activity from large area. Also, some investigators use the optical coherence tomography (OCT) to detect a tiny structural change occurring when nerves are activated. Other investigators detect neural activity noninvasively from intact human brain (diffuse optical tomography; DOT) by using the phenomenon that the neural activity is accompanied with a change in blood flow (neurovascular coupling).