The Oculomotor System

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# Part 1

## 1a) Solving the linear differential equation during saccade

To determine c, let t=0, θ=0:

Thus,

## 1b) Find F

Using Robinson’s constants ( , ):

### For 10° (45ms)

### For 20° (68ms)

### For 40° (110ms)

## 1c) Solve for the period after saccade

Since the eye is immobile, . As such, and .

## 1d) Plot pulse-steps

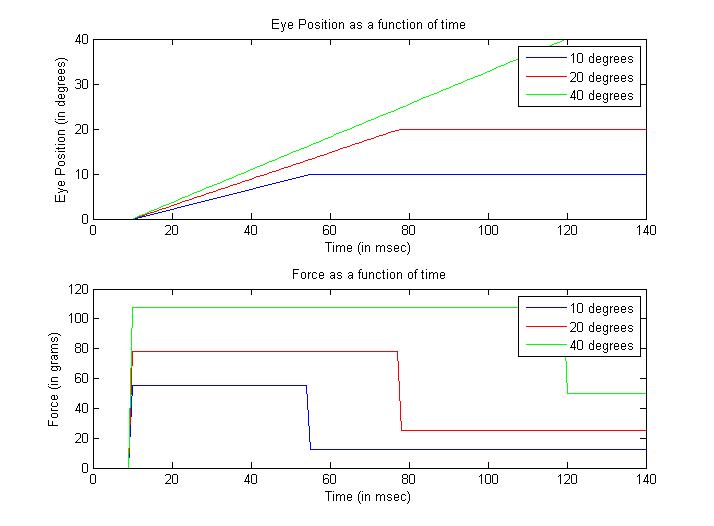


Figure : Eye Position and Force as a function of time. Saccades with increasing amplitudes require pulses that are stronger (force) and that last longer (time). They also require a higher force after the saccade to immobilize and maintain the eye at its position.

# Part 2

## 2a) Plant Diagram

Equation 2 from the previous exercise is a first order representation of the plant. It can be organized as such:

Likewise, the plant can be represented as such:

Thus, and .

This makes sense. It suggests that the force from the burst generator is subject to spring resistance k and some viscous resistance r as a function of change rate ().

## 2b) Box 1 and 3

### Box 1 Equation

### Box 3

Since , Box1 Box2

Thus, Box 3 contains . In other words, BG or the firing frequency, which is akin to velocity here, can be integrated over time to determine the eye position (in deg).

## 2c) Pulse-Step for a 40 degrees saccade

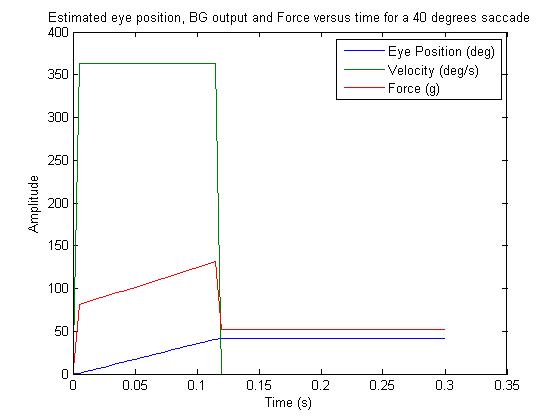


Figure 2: The Force Profile, Eye Position and Velocity for a 40 degrees saccade. The eye position gradually increases until it reaches 40°. The eye velocity is high during eye movement. The force increases over time during the saccade, then shoots to a lower force to keep the eye at its position following saccade.

## 2d) Plant Equation 2 Solution

For different values of t and y, we first interpolate the force profile using interp1, then use ode45 to solve the differential equation.

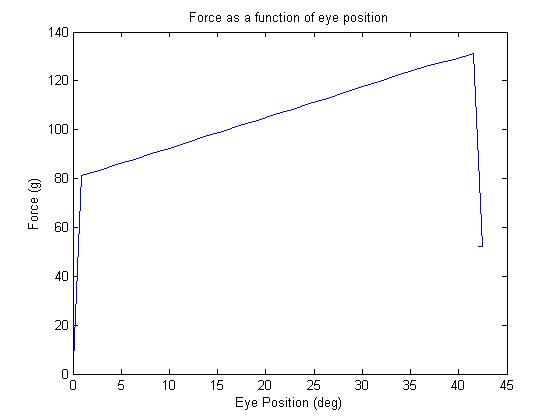


Figure : Force profile as a function of eye position. The force increases as it is pulling the eye, but decreases once it reaches the desired saccade.

## 2e) Eye Position vs Time

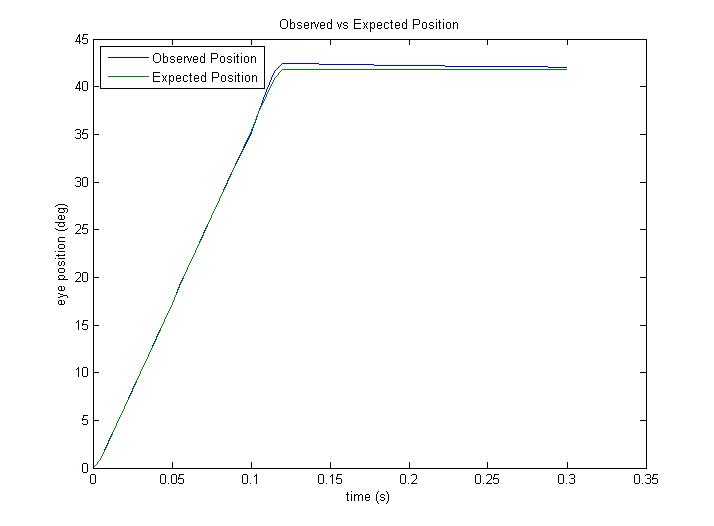


Figure : Observed vs Expected Eye Position. The Expected Eye Position is the Desired Eye Position from our Burst Generator. The Observed Eye Position is the Actual Eye Position as a function of a force and the eye properties. The shocking similarity between the two models suggests that Box 1 and Box 2 are almost identical, thus ff from the burst generator = force on the eye.

## 2f) Deficient Integrator Output, Resultant Eye Trajectory

Simply dividing the k constant by 2 to calculate the loop output force temporal profile should do the trick (but keeping the original k when using the plant equation).

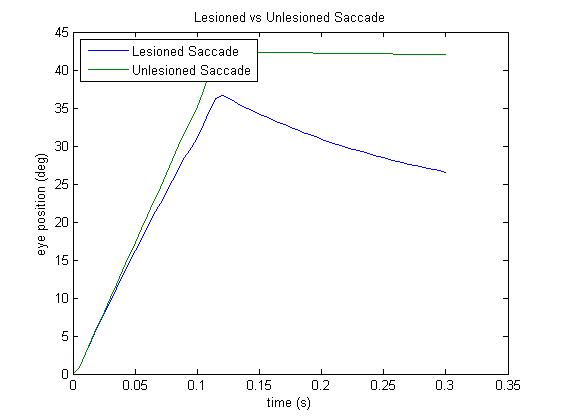


Figure : Eye Position for a 40 degrees saccade in a normal vs deficient integrator output. The lesioned integrator fails to produce the proper firing frequency to attain the desired eye saccade. As a result, the eye is incapable of reaching 40 degrees. Worse, the force following the saccade is insufficient to maintain the eye immobile, and the eye leans towards the midline (0 degrees).