Human-Machine Systems Exam August 2005 – Solutions

1 Crossover model theorem

Consider a general closed loop manual control task. The system to be controlled is described by $H_c(j\omega)$ and the pilot dynamic control behavior is given by $H_p(j\omega)$. The reference signal is i, the output is y, the error is $e = i - y$ and the system input is u.

[a] The human controller adapts his/her control behavior to the dynamics of the system to be controlled. McRuer and his colleagues have captured this adaptation in a theorem, the Crossover Model Theorem.

Describe this theorem in the frequency domain, i.e. in terms of $H_c(j\omega)$ and $H_p(j\omega)$.

[b] Consider the single-axis manual control task, a following task with a compensatory display. The dynamics of the system $H_c(j\omega)$ to be controlled are:

$$H_c(j\omega) = \frac{1.0}{j\omega(j\omega + 0.2)}. \tag{1.1}$$

The bandwidth of the input forcing function ω_i is 2.0 rad/s.

Draw a Bode plot of the system to be controlled.

[c] Assume that the human controller will adjust his/her control behavior $H_p(j\omega)$ to the system to be controlled $H_c(j\omega)$. What model *structure* would you choose, in terms of the Simplified Precision Model. Explain your answer.

[d] Determine the model parameters τ_L, τ_I and τ_e according to McRuer's Verbal Adjustment Rules. Compute the crossover frequency ω_c, the phase margin ϕ_m and the value of the model parameter K_p.

[e] A graduation student has implemented a single-axis manual control task, a following task with a *pursuit display*. The dynamics of the system $H_c(j\omega)$ to be controlled are:

$$H_c(j\omega) = \frac{1.0}{j\omega(j\omega(j\omega + 2.0))}. \tag{1.2}$$

The bandwidth of the input forcing function ω_i is 1.0 rad/s.

Explain using a sketch what the main differences are of this particular tracking task with respect to the task conducted in the previous question.

[f] Can the system be controlled? Explain your answer. Is this something that can be predicted using the Crossover Model?

[g] In order to improve performance, the student includes a *prediction symbol* on the display. The prediction symbol shows what the output of the system will be after T_p seconds, using a first order prediction algorithm. That is:

$$y_p = y + \dot{y}T_p, \tag{1.3}$$

with y the output of the system, y_p the position of the predictor symbol on the screen, and T_p the prediction time.

Does the addition of the prediction symbol help the operator in controlling the system H_c? Explain your answer.

[h] Does the operator change his/her control strategy when the prediction symbol is included?

[i] How would you choose the value of the prediction time T_p.

1 Solution

[a] The crossover theorem states that human controllers adjust their control behaviour to the dynamics of the controlled element in such a way that the dynamic characteristics of the open loop transfer function in the crossover region can be described by

$$H_{OL}(j\omega) = H_p(j\omega)H_c(j\omega) = \frac{\omega_c}{j\omega}e^{-j\omega\tau_e}. \tag{1.4}$$

This implies that the human controller transfer function in the crossover region is given by

$$H_p(j\omega) = \frac{\omega_c}{H_c(j\omega)j\omega}e^{-j\omega\tau_e}. \tag{1.5}$$

[b] We can split the system transfer function up into three parts.

$$H_{c1}(j\omega) = 5, \tag{1.6}$$

$$H_{c2}(j\omega) = \frac{1}{j\omega}, \tag{1.7}$$

$$H_{c3}(j\omega) = \frac{0.2}{j\omega + 0.2}. \tag{1.8}$$

We find that $H_{c1}(j\omega)$ is a constant. Its gain is $20\log(5) = 14$ dB and its phase is zero. $H_{c2}(j\omega)$ is an integrator. Its gain (in dB) is zero at $\omega = 1$ and has a slope of -20 dB/decade. Its phase is constant it $-90°$. $H_{c3}(j\omega)$ has roughly a zero gain for $\omega < 0.2$. For $\omega > 0.2$ the gain has a slope of -20 dB/decade. The phase varies from $0°$ to $-90°$. Adding up these three graphs gives us the Bode plot shown in figure 1

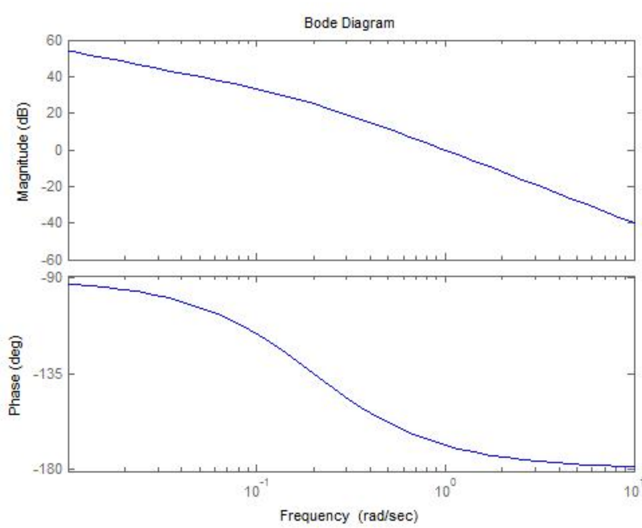

Figure 1: The Bode plot of $H_c(j\omega)$.

[c] The controller transfer function is given by

$$H_p(j\omega) = \frac{\omega_c}{H_c(j\omega)j\omega} e^{-j\omega\tau_e} = \omega_c(j\omega + 0.2)e^{-j\omega\tau_e}. \tag{1.9}$$

A good idea for the pilot model structure is thus given by

$$H_p(j\omega) = K_p(1 + \tau_L j\omega)e^{-j\omega\tau_e}. \tag{1.10}$$

[d] From the pilot model structure directly follows that $\tau_I = 0$ s and $\tau_L = 5$ s. The crossover frequency of the whole system will surely be bigger than 0.2 rad/s. So in the crossover region (with ω near ω_c) the system behaves itself like K_c/s^2. Using this fact, we can look up that $\tau_0 = 0.50$ s and $\Delta\tau(\omega_i) = 0.065\omega_i$. This implies that

$$\tau_e = \tau_0 - \Delta\tau(\omega_i) = 0.50 - 0.065 \cdot 2 = 0.37 \text{ s}. \tag{1.11}$$

We can also look up that $\omega_{c,0} = 3.3$ rad/s. So,

$$\omega_c = 3.3 + 0.18\omega_i = 3.3 + 0.18 \cdot 2 = 3.66 \text{ rad/s}. \tag{1.12}$$

This enables us to find the phase margin ϕ_m. We have

$$\phi_m = \frac{\pi}{2} - \tau_e\omega_c = \frac{\pi}{2} - 0.37 \cdot 3.66 = 0.217 \text{ rad}. \tag{1.13}$$

This is a bit of a small value, but that is to be expected.

To find the gain K_p, we can use the fact that the gain of the open loop system at the crossover frequency is 1. So,

$$\left|H_p(j\omega)H_c(j\omega)\right|_{\omega=\omega_c} = \left|K_p(1+\tau_L j\omega)e^{-j\omega\tau_e}\frac{1.0}{j\omega(j\omega+0.2)}\right|_{\omega=\omega_c} \tag{1.14}$$

$$= K_p\left|\frac{1+5j\omega_c}{j\omega_c(j\omega_c+0.2)}\right| \tag{1.15}$$

$$= 5K_p\left|\frac{1}{3.66j}\right| = 1. \tag{1.16}$$

This implies that

$$K_p = \frac{3.66}{5} = 0.732. \tag{1.17}$$

[e] The main difference between a compensatory display and a pursuit display is that in a compensatory display, the human controller gets as input only the error e. In a pursuit display, the human controller gets as input both the output y and the reference signal i. So, in the sketch of the control system, both these two signals should enter the block representing the human controller.

Other obvious differences between this problem and the previous one include the fact that the new system has an additional integrator, and the bandwidth is smaller.

[f] This kind of depends on where the crossover frequency will be put. If it is put at $\omega_c < 1$ rad/s, then it will be inside the bandwidth, which can cause instability. If it is put at $\omega_c > 2$ rad/s, then the system will behave like K_c/s^3, which is rather hard to control. However, if the crossover frequency is put in the interval $1 - 2$ rad/s (and preferably not too close to one of the edges), then it will be possible to control the system. So in principle it is possible to control the system.

This is not something that can be predicted with the crossover theorem, since the crossover theorem only applies to compensatory displays.

[g] Let's assume that we use a compensatory display. The human controller transfer function would then be given by

$$H_p(j\omega) = \frac{\omega_c}{H_c(j\omega)j\omega} e^{-j\omega\tau_e} = \omega_c j\omega(j\omega + 0.2)e^{-j\omega\tau_e}. \tag{1.18}$$

In this equation is a differentiator. (See the $j\omega$ term.) So to control the system, the human controller must keep track of how the system is changing. Adding a predictor symbol will give an indication of how the system is changing, and as such will help the human controller with his task.

[h] The predictor symbol gives an indication of $\dot{y}$. And, if the input to the system would be $\dot{y}$ (or alternatively, $\dot{e}$), then the transfer function of the system will change. That is, one of the $j\omega$ terms will vanish. This turns the human controller transfer function into

$$H_p(j\omega) = \frac{\omega_c}{H_c(j\omega)j\omega} e^{-j\omega\tau_e} = \omega_c(j\omega + 0.2)e^{-j\omega\tau_e}. \tag{1.19}$$

This is different than what it previously was. So it can be expected that the human controller will change his strategy. He will focus more on the prediction symbol.

[i] The time T_p should not be so big that nonlinearities make it meaningless. However, it should also not be so small that the human controller can't intervene in time. So it should be just a bit bigger than the lag τ_e. I would thus suggest to put it roughly near $T_p = 0.50$ s, though a slightly bigger value would also be acceptable.

2 Visual perception and visual displays

Consider an airplane flying over a flat surface at a height h above the ground. The world consists of lines perpendicular to the line of motion. The distance between the lines no the flat surface plane is 200 meters. This is called situation I.

[a] Which two effects play a major role in the perception of the velocity of self-motion? Explain their origin and, if possible, provide a mathematical background.

[b] Assume that the distance between the lines is reduced to 100 meters (situation II). The velocity V and height h of the observer remain the same. How does this affect the perception of the velocity of self-motion?

[c] Now, we decrease the height above the plan with 50% (situation III). How does this affect the perception of the velocity of self-motion?

[d] Do you think that the perceived velocity of self-motion is the same in situations I and III? Explain your answer.

2 Solution

[a] The first effect is the optical edge rate. This is the rate at which local discontinuities cross a fixed point of reference in the observer's view. If, for example, you are passing by a (regularly spaced) tree every second, you appear to be going a lot faster than if you are passing by a tree every four seconds.

The second effect is the global optical flow rate $V/h = \dot{x}/z$. The depression rate (that is, the rate at which the angle with respect to a certain object below you changes) is given by

$$\dot{\delta} = \left(\frac{\dot{z}}{z}\right) \cos\delta \sin\delta - \left(\frac{\dot{x}}{z}\right) \sin^2 \delta. \tag{2.1}$$

If the magnitude of the depression rate is big, then objects appear to be moving below you at a fast rate. So you perceive your velocity to be big. Assuming you are flying at a constant height (so $\dot{z} = 0$), the magnitude of the depression rate is proportional to the GOFR. So if the GOFR is big, you think you are moving fast.

[b] Changing the texture does not influence the GOFR. It does, however, influence the optical edge rate. According to this parameter, you appear to be going faster. (More lines are passing by every second.) So if the distance between the lines becomes smaller, you probably will think you are going faster.

(This same effect occurs with cars. When travelling in the city at 70 km/h, you think you're going fast, since a lot of things pass you by every second. But when travelling with 70 km/h on the high way, you think you're going very slow. Hardly anything passes you by every second.)

[c] Changing the height does not influence the optical edge rate. However, it does influence the global optical flow rate. This is because the global optical flow rate is given by V/h. Reducing the height also means that the magnitude of the depression rate increases. So you appear to be going faster.

(Now there's a plane analogy. When an airplane passes you by at 500 meters height, it doesn't appear to be moving very fast. In reality, of course, it is moving quite fast. And if the plane would be flying past you at 20 meters height, you would notice this.)

[d] Basically, the optical edge rate has increased and the global optical flow rate has increased. If both these things happen, your mind generally thinks that you are going faster. So the perceived velocity of self-motion in situation III is a lot higher than in situation I.

3 Abstraction hierarcy

The Abstraction Hierarchy (AH) as introduced by Jens Rasmussen can be used to map knowledge about a system at different levels of abstraction.

[a] Name the different levels of the Abstraction Hierarchy as described by Rasmussen. Give a description of the kind of representations at the different levels.

[b] Consider a 'holiday project' in which you want to roam around in a relatively uninhabited region, and you can take either a tent or a caravan to get shelter during the night. The goal of taking a tent or caravan is to have a mobile resting place. The following descriptions of a device for camping are from different levels in the abstraction hierarchy; mobile resting place, isolation, shelter, tent, caravan, mobility, light brown cloth and aluminum support, light weight, wheels.

Put the above descriptions at the proper levels in the abstraction hierarchy.

[c] Rasmussen distinguishes two concepts in relation to the abstraction hierarchy, reasons and causes. These concepts are used in reasoning upwards (to a higher level of abstraction) and downwards (to a lower level of abstraction).

Explain the concepts of reasons and causes as Rasmussen defines them.

[d] If you consider the abstraction hierarchy for design, i.e. reasoning from the goals you want to achieve, you can choose different solutions for achieving these goals, and end up with different systems, such as the tent and the caravan. Discuss where the tent and caravan have common representations in the AH and where they differ.

3 Solution

[a] There are five different levels in AH.

- *Functional purpose* – This level describes the goals of the system, which usually is some desired state of the environment.
- *Abstract function* – This contains high level functions, like the physics function which describe the world. (Think of mass and energy conservation laws.)
- *Generalised function* – This level contains functions which describe the processes in the system. (Think of applied aerodynamics/thermodynamics laws.)
- *Physical function* – Here we describe the functions of the actual physical parts of the system. (I.e. what are the functions of all the system parts?)
- *Physical form* – What form do the physical parts of the system have?

[b] We can divide the descriptions accordingly.

- *Functional purpose* – shelter, mobile resting place.
- *Abstract function* – mobility, isolation.
- *Generalised function* – light weight.
- *Physical function* – tent, caravan.
- *Physical form* – light brown cloth and aluminum support, wheels.

[c] In the AH are several levels. The higher level elements are the *reasons* for the lower level elements. (For example, the reason a tent has mobility is because it needs to be a mobile resting place. And it needs light weight to have mobility.) In fact, they are reasons for the proper function requirements of these lower levels.

Similarly, lower level elements are the causes of the higher level elements. (For example, the fact that cloth and aluminum has been used causes the tent to be light weight. And this causes the tent to be mobile.)

[d] The tent and the caravan have the same functional purpose: they both provide shelter and offer a mobile resting place. The abstract function is also the same: both the tent and the caravan have mobility (though the tent somewhat more). The difference comes in at the generalised function: a tent is light weight, but a caravan is not very light weight. (Although, compared to an actual house, a caravan can still be considered as light weight.) Of course, the physical function of the tent and the caravan are completely different. (A tent is a tent and a caravan is a caravan.) And this implies that the physical form is also very different. A caravan does not have light brown cloth as outer hull, and a tent generally does not have wheels.

4 Human error

Background: The following is an excerpt from an accident report. The approach was flown with a DC-9. This type of DC-9 was equipped with a High/Low/Off hydraulics system. In the Low position, the hydraulics system provides enough power for use in-flight. The hydraulics must be set to the High position to provide enough power for the landing gear and the flaps. Checking that the hydraulics are set correctly is part of the in-route checklist.

The First Officer is the pilot flying, the Captain is the pilot not-flying, this means that he must make the configuration changes and supervise the aircraft systems. Any diagnostic tasks are primarily to be carried out by the PNF.

In this company, the rule called the 'sterile cockpit rule' must be adhered to. This means that any irrelevant conversation or activity may not take place during critical phases of the flight.

At 0840:42, air traffic control (ATC) at Houston Center issued a clearance to flight 1943 to descend from the en route altitude of 35,000 feet to 13,000 feet mean sea level. The first officer began the descent, and the captain performed the descent checklist.

At 0845:31, the first officer called for the in-range checklist. Between 0845:37 and 0846:10, the captain referred to each of the seven items on the in-range checklist, in the correct order, except for the fourth item, 'Hydraulics,' to which the captain did not refer. The first officer responded 'checked set' to the third item, 'Flight Instruments, Altimeters,' and 'on' to the fifth item, 'Shoulder Harness.'

Flight 1943 received clearance to descend to 10,000 feet at 0847:12. At 0848:39, the captain made initial contact with the Houston Terminal Radar Approach Control Arrical East controller and requested runway 27. At 0849:33, the controller cleared flight 1943 to descend to 7,000 feet. At 0853:23, the controller instructed flight 1943 to 'join the two seven localizer' and descend to 4,000 feet.

At 0854:49, the first officer called for the approach checklist. Between 0854:49 and 0855:18, the captain referred to the first four of the nine items on the checklist. At 0855:27, the checklist was interrupted by the first officer informing the captain that he intended to use manual spoilers and 40° of flaps for landing. The captain resumed completing the checklist at 0855:56, and accomplished the next three items before he was interrupted again at 0856:06, when the controller transmitted 'Continental nineteen forty three, thirteen miles from the marker, maintain two thousand till established on the localizer, clear ILS two seven approach.' At 0857:02, the controller instructed flight 1943 to maintain a speed of 190 knots or faster to the outer marker and to contact the tower. According to the captain, the ATC request to maintain 190 knots or faster to the marker was not unusual at IAH on a visual flight rules (VFR) day. In his post-accident statement, the captain reported that at the time ATC made the request, the airplane's indicated airspeed was approximately 210 knots, so no speed adjustment was necessary.

After making the landing public address (PA) announcement, the captain contacted the Houston Intercontinental Air Traffic Control Tower Local East controller, and at 0857:58, the flight was cleared to land. At 0858:08, the captain said 'now, where was I,' referred to the last two items on the approach checklist, and stated 'approach check complete.'

At 0858:48, the captain commented 'aw shoot. I can't play tennis when it's like this... well maybe this afternoon it'll clear up. Actually I've still got a lot of time.' At 0859:00, the first officer said 'go slats and five.' After the CVR recorded the sound of a click at 0859:03, the captain stated 'slats are going to five.' The captain later recalled that he felt the slats extend, and the first officer recalled that the blue 'SLATS EXTENDED' light illuminated. Between 0859:14 and 0859:37, the captain engaged the first officer in nonessential conversation about the weather. At 0859:50, the first officier initiated dialogue with the captain to clarify whether the controller had asked them to maintain 190 knots to the outer or middle marker. The discussion ended at 0900:00, when the first officer commented 'heh' and then made two remarks, of which only a few words were intelligible on the CVR recording. In a written statement submitted to the Safty Board on January 27, 1997, the first officer reported that he had noticed the flap gauge indicating 0° at 0900:00 and that his subsequent remarks had been in reference to the flap gauge. At 0900:11, the captain reported the airport in sight.

At 0900:13, after crossing the outer marker, the first officer called for the flaps to be extended to 15°. During an interview on February 20, 1996, and in his written statement dated February 27, 1996, the first officer indicated that at this point he realized that the flaps had not extended and touched the flap gauge to show the captain that it indicated zero. According to the captain, he responded by confirming that the flap handle was positioned to 15°. At 0900:33, the captain said 'I think the flaps <<unintelligible>>.' At 0900:35, three intermittent sounds from the landing gear warning horn were produced, according to the first officer, by the captain rapidly moving the throttles back and forth. At 0900:37, the captain said 'well we know that, you want the gear.' At 0900:38, the first officer called 'gear down,' and 2 seconds later, the CVR recorded the sound of [the gear handle]. At 0900:41, the first officer called for the landing checklist and the flaps to be extended to 25°. At 0900:46, the gear warning horn began to sound. During the next 12 seconds, the first officer called for the flaps to be extended to 40° and then to 50°. At 0901:00, the first officer stated 'I don't have any flaps.' In his postaccident statement, the captain reported that 'the aircraft did not feel as though we had 50 flaps (didn't balloon and aircraft didn't slow).' The CVR does not indicate that the landing checklist was ever started.

The aircraft made a crash landing with the gear up and the flaps at 0 degrees.

Explain the difference between latent and active errors.

Identify the slips/lapses and mistakes made by the captain and the first officer, and classify them according to the Rasmussen levels of behaviour (if possible). Try to find at least four errors!

4 Solution

An active error is an error with (nearly) immediate consequences. On the other hand, a latent error is an error with delayed consequences. Only after days, weeks or years will the consequences take place.

Now we'll examine a few errors that have been made.

- *Between 0845:37 and 0846:10, the captain referred to each of the seven items on the in-range checklist, in the correct order, except for the fourth item, Hydraulics, to which the captain did not refer.*

  This is a slip. The intention was correct (the captain wanted to go to the next item in the checklist) but the captain accidentally skipped an item. So the action did not have the desired effect. Because this error is a slip, it has to be a skill-based error.

- *'the first officer ... realized that the flaps had not extended and touched the flap gauge to show the captain that it indicated zero. According to the captain, he responded by confirming that the flap handle was positioned to* 15°*.'*

  It seems that the first officer realized that the flaps had not extended. Yet there is no sign that he tried to find out why this wasn't the case. And soon after that, he ordered the flaps to be extended further, ignoring his previous conclusion. This is an error. It would be normal for pilots to have the rule that when something doesn't seem right, attention should be paid to this anomaly. The pilot and the copilot apparently didn't have this rule. So this is a rule-based error.

- *'the first officer ... realized that the flaps had not extended and touched the flap gauge to show the captain that it indicated zero. According to the captain, he responded by confirming that the flap handle was positioned to* 15°*.'*

  Apparently, it is possible to move the flap handle to a different position, while the flaps are disabled. (The flaps are disabled because the hydraulics are in the low position.) And this doesn't give a warning. As was proven in this crash, this can be confusing for pilots. The designers of the airplane should have built in a warning of some sorts when the flap handle was moved, while the hydraulics were in the low position.

  This error is a knowledge-based mistake. This is because the aircraft designers, when designing the aircraft, didn't look enough ahead in time to foresee an event like this.

- *'At 0900:35, three intermittent sounds from the landing gear warning horn were produced, according to the first officer, by the captain rapidly moving the throttles back and forth.'*

  The captain moved the throttle back and forth so rapidly that a warning horn was sounded. This isn't normal procedure and thus has to be some kind of error. In fact, it is a slip. The intention of the pilot was to reduce the throttle, but it could not have been the intention of the pilot to sound the warning horn. Since the error is a slip, it has to be a skill-based error.

- *'Between 0859:14 and 0859:37, the captain engaged the first officer in nonessential conversation about the weather.'*

  This is not allowed in the company. And it may have distracted the pilot and the copilot from their duties, reducing their situational awareness. In fact, this is a mistake. This is because the intention of the pilot (engaging in irrelevant conversation during the landing phase) was wrong. Also, because the pilot did not apply the normal rules here, this must be a rule-based error.

5 Vestibular system

Prolonged exposure to a zero-gravity environment, such as during interplanetary flight, can lead to reduction of bone and muscle strength. To prevent these conditions, people have proposed the use of rotating spacecraft ('wheels etc.') where the centripetal acceleration provides an artificial gravity.

[a] If the threshold for perception of angular velocity is 0.1 deg/s, how large should the spacewheel have to be to generate a 5 m/s^2 artificial gravity with a rotational rate that is below the threshold for perception of angular velocity?

[b] If a smaller wheel is used, with a rotational velocity above the threshold for perception, e.g. 10 deg/s, describe the sensations that a person in the wheel would feel who, after standing with his face in the direction of wheel velocity, would turn 90 degrees to the left, now facing the direction of the rotation vector. Assuming an axis system fixed to the head with x pointing forward, y pointing to the right and z pointing down, sketch the rotational sensations around the x and y axes.

[c] What would be the best orientation for a bed if we want to minimize the effects on a person sitting up from a position lying on his/her back?

[d] Assume a sleeping orientation with your feet in the direction of the rotation vector. Should you have the wall of the cabin on the left or right side of the bed (assuming a position lying on your back in the bed), to minimize the risk of falling out of bed if you sit up from a lying position? Explain your answer.

5 Solution

[a] We have $\omega_{max} = 0.1$ deg/s $= 0.00175$ rad/s and $a = 5$ m/s^2. This implies that

$$a = \omega_{max}^2 r_{min} \qquad \Rightarrow \qquad r_{min} = \frac{a}{\omega_{max}^2} = \frac{5}{0.00175^2} = 1.64 \cdot 10^6 \text{ m}. \tag{5.1}$$

[b] First the rotation is about the y axis (positive) while after that the rotation is about the x axis (negative). (In-between there is a short negative rotation about the z axis.) However, the specific force points in the direction of the z axis all the time. So the person won't be confused about the vertical: his subjective vertical will not change. He will notice that the angular velocity (with respect to his body) changes direction.

[c] The best way would be to orient the bed such that the test person is NOT moving sidewards. Instead, he should move in the direction of his feet or his head. If this is the case, then sitting up will not change the direction of rotation. It would thus be similar to sitting up on Earth. And humans are already sufficiently used to that.

[d] When you have your feet in the direction of the rotation vector, you are moving to your left. Initially, we are having a (positive) rotation about the z axis. After sitting up, we have a (positive) rotation about the x axis.

By sitting up, you get rid of your (positive) rotation about the z axis. Your brain will see this as a negative angular acceleration about the z axis. This will mean that the subjective vertical will move counterclockwise (as seen from above your head). The vertical used to point in the negative x-axis. Because of the counterclockwise rotation, it will be pointing in the direction of the positive

y axis. So, right after sitting up, your brain will think that gravity points to the right. Your body will compensate by moving to the left.

Coincidentally, leftward is also the direction of the coriolis force acting on your head. By sitting up, the radius – i.e. the distance from the center of rotation – of your head has decreased. So the coriolis force will make it accelerate in the direction it is currently moving: the left.

Because of both effects, your body will move to the left. It would thus be best to place the wall on that side of the bed, so you at least don't fall out of your bed. (Though it would still be better to sleep on the ground. This is safer and a lot less expensive, as you don't have to bring a bed into space.)

6 Visual perception and visual displays

[a] What are the two phases in visual processing?

[b] Consider figure 2, illustrating an important visual effect. Describe the visual effect that you experience.

[c] What is causing this effect to happen?

[d] How can we use this effect in designing interfaces?

Figure 2: One vase or two faces?

6 Solution

[a] The first phase is the preattentive phase. The brain then organizes the visual world into objects and groups of objects. Objects are often grouped together when they are close together, when they lie in a line/curve and/or when they look alike. In the second phase, called focal attention, we then limit our attention to a certain (group of) objects.

[b] I experience that I can see a vase in the picture, or I can see two faces in the picture. But, no matter how hard I try, I cannot see both the vase and the two faces simultaneously.

[c] This effect is called the figure-ground organization effect. The brain has trouble figuring out what is the figure and what is the ground behind it. Once it has accepted one part of the figure as the actual figure, the other part is condemned to be the ground. That is the reason why you cannot see both figures simultaneously.

[d] The figure-ground effect allows two figures to be displayed in one image. This allows for the condensing of data in displays and as such could be used in interface design.

However, it is sometimes hard for the brain to decide which images it sees as the actual figure. For this reason, I would advise against using this effect in interface design. It might just occur that a very important piece of data is displayed in one image, and all the pilot can see at that moment is the other image. This could very well result in problems.