CS6750 Summer 2021 – Assignment P2

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1 QUESTION 1

I am a private pilot with around 20 years of experience, so for this question I chose a set of tasks revolving around flying a small general aviation aircraft. Note that this exercise was performed in an FAA approved flight simulator – this provides an environment very similar to actually being in the cockpit allowing me to divert more attention onto interpreting tasks as they related to the assignment without sacrificing safety.

Task	**Goal**	**Interface**	**Object(s)**
Fly the plane	Maintain level flight	Control Yoke / Rudder Pedals	Ailerons, elevator, rudder
Tune radios	Communicate with air traffic control	Radios	Air traffic controller
Lean engine	Set fuel-air ratio	Mixture lever	Carburetor / Engine
Enter navigation waypoint	Fly to destination	GPS	Navigtion waypoints
Perform pre-landing checklist	Ensure airplane is properly configured for landing	Paper checklist	The airplane

1.1 Task 1 – fly the plane

While flying a plane to a destination, the goal is to maintain straight and level flight. There is an idiom of "aviate, navigate, communicate" meaning safely flying the plane is the number one objective before navigation or communication. Maintaining the plane's attitude and heading is performed by manipulating the yoke and rudder pedals, which in turn manipulate the ailerons, elevator, and rudder. Even though in general aviation there are rigid or cable linkages from the controls to the control surfaces, the pilot does not manipulate the control surfaces directly, nor do they force the plane to change orientation directly – it's all a result of changing the aerodynamic forces.

Similar to driving a car, this is an invisible interface that was made so through learning. When first learning how to fly, pilots spend a lot of time developing "stick and rudder skills" where they how to manipulate the interface. Given sufficient training, this manipulation becomes natural and the interface disappears.

1.2 Task 2 – lean engine

In older aircraft, the fuel-to-air ratio is optimized in a process known as "leaning the engine." This involves manipulating a mixture lever which adjusts a carburetor to control the amount of fuel sent to the engine. A properly leaned engine is being provided with enough fuel to continue operation without burning excess fuel.

This is not a direct operation as the pilot must rely on information from different instruments in addition to auditory cues to determine when the appropriate fuel-air mixture has been achieved. With enough practice it's not something that a pilot thinks much about so the interface is invisible through learning.

In some modern aircraft the carburetor has been replaced with fuel injection and the correct fuel-air mixture is set automatically – in those cases, the interface is completely invisible to the pilot / user by design.

1.3 Task 3 – enter navigation waypoint

One common way of navigating to a destination while flying is to enter a destination via GPS, much like one would do in a car. Rather than providing a set of directions involving a series of turns, the pilot is presented with a virtual line on a flight instrument that they should follow.

Compared to older means of navigation that could involve complex calculations, tuning of radio frequencies and navigating to different waypoints, this is a much more direct method of navigation. Even compared to visual navigation done by a practice called "dead reckoning" where a pilot visually navigates to known waypoints such as highways or geographic landmarks, this is even more direct because you follow the exact path to the destination.

This is an example where the interface has been made invisible through design.

1.4 Task 4 – pre-landing checklist

Throughout all phases of flight, pilots employ the use of various checklists to ensure that the airplane is properly configured for the task. One such checklist is the pre-landing checklist. This checklist is actually a compilation of a number of tasks to meet the goal of properly configuring the airplane for landing.

It is not a direct interface because the interface is a piece of paper with written directions and the object of manipulation is various controls, however it is invisible through learning. Aviation safety stems from good training and regimented procedures. Through training, pilots learn to follow these checklists as second nature, thereby making them invisible. In some modern cockpits, paper checklists have been replaced with digital ones; these can integrate directly with the aircraft systems and know directly if a task has been completed vs having to manually check of an item on a paper checklist.

2 QUESTION 2

For this question, I'm focusing on the task of flying a plane in IMC (instrument meteorological conditions). This is a situation where the pilot is unable to use outside visual references to maintain attitude of an airplane and must rely on information from cockpit instruments. Level attitude can be maintained solely from looking at the attitude indicator (the center instrument in the top row of the following figure), however, all pilots are trained to validate that information by cross-referencing information from a combination of other instruments, such as the turn indicator and compass (lower left and lower center instruments) to mitigate the effects of the failure of an instrument or system.

Figure 1 — Instrument panel from a Cessna 172, ref: https://farm3.staticflickr.com/2233/2335176389_4bc114224f_b.jpg

This type of flying requires an immense amount of training to become proficient – in the beginning there is an extremely high cognitive load required to interpret the information being provided and process it in order to ensure that no conflicting information is provided. Given enough *concurrent* practice this processing becomes second nature, and the cognitive load is reduced. Scanning the instrucments becomes intuitive and not much thought is placed into it – it's similar to a muscle memory and the interface essentially becomes invisible. However, this is a skill that also rapidly deteriorate, removing the invisibility of the interface. The FAA recognizes that instrument flying proficiency can deteriorate over time and mandates minimum IMC flight hours over a proceeding period in order to maintain currency.

Modern glass cockpits like the one shown below have essentially redesigned the interface to provide the pilot with attitude information in a way that closely mimics the natural world.

Figure 2 — Garmin G1000 NXi artificial horizon interface in a modern Cessna 172. Ref https://cessna.txtav.com/en/piston/cessna-skyhawk#_model-avionics

In this interface, an artificial digital horizon is presented to the pilot that closely mirrors what would be observed if looking outside the cockpit. All the information from the analog instruments is still present, however it is presented in a way that is natural for humans (not just pilots) to interpret, thereby reducing the cognitive load required.

3 QUESTION 3

For this question, I have chosen the task of cooking a steak in a cast iron skillet.

3.1 Visual perception

Visual feedback is obtained because the steak will physically change its appearance as its being cooked. The Maillard reaction causes a caramelization sugars in the food leading to the browning of the exterior of the food. This is an indicator that the food is actually being cooked.

Conversely, this same act does not give any visual perception to the cook state of the interior of the steak. Through enough practice one can develop an intuition as to how long to cook a steak to reach the desired interior doneness, but this is extremely difficult to accurately predict based solely on the visual doneness seen on the exterior of the steak. In this case, the pan could be augmented with an instant read probe thermometer that can give a visual readout of the internal temperature.

3.2 Auditory perception

Next is the auditory feedback from cooking a steak in a skillet. One can hear an audible "sizzle" as the steak cooks. If the temperature is too low, that sound goes away, but if the temperature is too high, the characteristics of the sound change – the pitch is different and there are a lot more audible pops. Audial cues can be used to gauge if an appropriate cooking temperature is being used. When cooking on a gas range, one can also hear the flow of gas, which directly correlates to the heat produced.

Electric and induction ranges are silent in the production of heat. While the auditory cues from the cooking of the meat are all still present, you lose the ability to hear the sound of the heating. On an electric or induction range, this could be augmented by providing a small audible tone that changes pitch depending on how much electricity is being used.

3.3 Haptic perception

While cooking a steak, the most apparent haptic feedback is the heat radiating from the pan. This is direct feedback of the cooking temperature. With enough practice a cook can sense the appropriate temperature through feel.

One application that doesn't have haptic feedback that could benefit from it is tamping espresso grounds. After ground coffee is placed in a portafilter, the grounds need to be compacted using a tamper for proper coffee extraction. The best tamping pressure is around 35lbf. This is a quantity that's difficult to gage without practice, so a tamper that provided a "click" (similar to what is felt by a torque wrench) when the appropriate tamping pressure is reached would provide valuable haptic feedback.

3.4 Smell perception

Smell is a different kind of perception that is obviously used while cooking. Caramelization not only changes a food's physical appearance but also its smell. The absence of those smells could indicate that something isn't done cooking or not enough heat is being applied. Likewise, a burning smell would indicate that something is past done or too much heat is being applied.

4 QUESTION 4

4.1 Giving user control of the pace

When I watch lecture videos (in this class as well as others), I keep the video player on one side of the screen and use OneNote to type notes as the videos play. Compared to traditional in-person lectures, online lectures are far more produced and pack much more information into a shorter amount of time. Because of this, it is often difficult to keep pace with the videos while taking notes. There are available keyboard shortcuts for play and pause, but none (that I'm aware of) that allow a user to easily scrub (jump forward and back in a video) within a video. I could also take my hands off the keyboard and use a mouse to select the video window and jump back an undetermined period of time, but its often difficult to know how far you need to step back to replay a key piece of information. The act of using a mouse and switching windows also interrupts the note-taking workflow.

The simplest way to improve this interface and give more control over the pace would be to add keyboard shortcuts to jump back 10-15 seconds similar to how there's an OS-level shortcut for play/pause.

A more complicated-to-implement but natural-to-use interface could come through the use of a webcam and microphone. If I'm in a physical lecture hall and would like the professor to stop and clarify a point, I can raise my hand or call out to the professor and ask them to go back.

An voice interface that allows the user to easily pause or skip around in a video wouldn't require the user to take their hands off the keyboard and interrupt the note-taking process. A video gesture based interface (ie raise your hand to pause, swipe left to scrub backwards, swipe right to scrub forward) would require temporarily stopping the note taking process, however it has the benefit of not changing the window focus like using a to operate the video controls.

4.2 Offloading tasks from the user to the interface

For the past six months I've had the same breakfast every weekday morning – a poached egg on an English muffin. The egg is cooked in a sous vide bath and the muffin is toasted in an over, both of which are IoT devices that can be voice controlled by means of Amazon Alexa.

My routine involves asking Alexa to pre-heat the sous vide bath to a pre-determined temperature when the alarm goes off in the morning. After pre-heating, the egg is placed in the water bath and a timer is set for ten minutes. After five minutes, I then place an English muffin into the toaster and ask Alexa to cook an English muffin. The toaster oven will automatically shut off, however after the gg is done cooking I have to manually turn off the sous vide appliance (again via Alexa – there is no physical interface on my particular unit).

The task in this case is not to preheat the water bath, set a timer, and cook the muffin, but rather simply to cook my breakfast. There are some times I forget to start cooking my muffin (I haven't had my coffee at this point) or forget to turn off the sous vide appliance afterwards. The Alexa interface could be improved by understanding that I'm not trying to accomplish each individual task, but rather the larger breakfast cooking task. By having a better understanding of my actual task, it could offboard some of the tasks from the user by automatically preheating the sous vide bath (or asking to do so) when my alarm goes off.

When I place an egg into the water bath (determined by a drop in the water temperature) it could automatically start a timer and remind me through an alarm to place a muffin in the toaster so it can be toasted (my toaster oven has a camera and object detection algorithms). Offloading these tasks would make the process easier and allow me to focus on something more important in the morning – making my coffee.