Entertainment control: the TV case study

Avi Harel, Ergolight

ergolight@gmail.com

Abstract

The entertainment case study exemplifies design mistakes typical of feature-driven control, such as in popular home systems, and proposes a methodology of intention-driven control, for enforcing seamless operation. The problem of feature-driven control is that it enables use errors. Intention-driven control enforces seamless operation by eliminating use errors. Generic rules, applicable to all interactive systems, are obtained by abstraction of specific rules examined for entertainment control.

The TV system

Case study: control confusion

The case study is an entertainment sub system of the smart home. The devices in the case study are a screen monitor, and two sources (S1, S2) of entertainment content. The control unit comprises:

- A pad with an On-Off toggle button and navigation buttons for operating the screen and the two sources,
- A control selector, enabling to divert the pad commands to the screen or the sources, and
- A source selector, enabling to select the active source.

Risk study

The study is of the risks involved in four different cases of user intentions regarding the user activity in browsing source S1

Cases of control failure

1. User intention: Turn source S1 on

- Operational procedure
  1) Select source S1 from sources menu
  2) Toggle on-off button
- Optional failure:
  - selection error
  - Optional failure: what if source S1 was already on?

2. User intention: Turn TV screen on

- Operational procedure
  1) Select screen control
  2) Toggle on-off button
- Optional failure:
  - Optional failure: selection error
  - Optional failure: what if the TV screen was already on?

3. User intention: Select source S1 connection to TV

- Operational procedure
  1) Select source S1 from sources menu
  2) Optional confusion: selection error
- Optional failure:
  - Optional failure: source S1 is off
  - Optional failure: TV screen is off

4. User intention: Browsing channels of source S1

- Operational procedure
  1) Using the navigation buttons
- Optional failure:
  - Setting error due to source selection error

Many of the elderly find this method very difficult to use. Often, they select the wrong device, resulting in operating in exceptional situations, in which the system seems dead, or does not operate as intended. Often, they need to call for technical assistance, or to ask people of a newer generation to help them with the operation. These problems repeat often, and many people give up using these systems.

The design challenge is to eliminate the feasibility of this kind of mishap.

Methodology

Topics that we need to concern in designing the control of smart homes

- Error prevention, to enable users to focus on their primary tasks
- Error root cause analysis (RCA), to identify design mistakes enabling the errors
- Integration engineering, to disable failure by design rather than detection in testing
- A model of operational risks, for comprehensive protection design
- Intention driven interaction
- Exception handling
- Rule-based implementation

Details about the methodology are available in Harel (2024 B)

Situational risks

Situational risks may be classified as either external or internal:

- External risks are about uncontrollable variables, such as environmental conditions and other contextual parameters. Externally, normal operation must be in the performance envelope. External risks are due to approaching the performance boundaries, defined as limits of performance variables.
- Internal risks are about controllable variables, such as service performance and modes, which the operators may set and change. Internally, the situations must comply with the scenario, as perceived in the controller. Internal risks are due to diversion from the situations defined as normal. In this case study, the diversion was attributed to selection error.

Situational complexity

Internal situational risks may be attributed to difficulties in situation coordination, due to situation complexity: the number of possible situations grows exponentially with the number of state machines employed in the system operation. In the case study the complexity is the multiplication of the complexities of the state sets: of the devices monitor, source S1, source S2, and the complexities of each unit is the multiplication of the sizes of the state sets of their parameters affecting their behavior. The risk of setting any of these state sets erroneously is linearly correlated with the complexity, which is very high.

These mappings define normal situations. All other situations should be regarded as exceptional.

Intention-driven interaction

Normal operation is task driven, and subject to proper coordination between the human operator and the system. For example, we may prevent human errors by automation, by mapping intentions to situational vectors, formulated as intention-driven situation rules. These solutions have been demonstrated in the context of radiotherapy (Harel, 2024 A).

The operator issues commands or requests to the system, and the system provides reports on its situation and activity. In this case study, the user's tasks include monitoring based on source S1 and source S2. The operation should enable selection of the desired source, activation, and turning the system off.

Mode errors

Mode errors are special, common sources of activity errors when the user is not aware of a change in the operational mode. They occur when a user misinterprets the current device mode, leading to actions that are appropriate for an incorrect mode. Examples:

- A critical feature is not available, because it was disabled earlier for maintenance
- Unnoticed mode set by default, when recovering from intermittent power failure
- Use cases competing on setting the mode of the same device.

An example, as demonstrated in this case study, is when a user is trying to control one device but is approaching a different device instead. The design challenge is to eliminate mode dependent activity.

Scenario-driven operation

Scenarios may be used as situation vectors, namely, pointers to the set of states of the system units, thus, reducing the situational complexity from exponential to linear. Situational consistency may be enforced by a mathematical function, defined by a mapping from scenarios to a vector in the space of the states of the system units. Accordingly, a situation is consistent with a scenario if it is identical to a projection of such mappings. In the entertainment control example:

- The scenarios are Source S1, Source S2, and Idle
- The situation space consists of those of the TV Monitor, Source S1, and Source S2.
- The situational mapping: Scenario ➔ (TV situation, Source selection, Source S1 situation, and Source S2 situation) where each unit situation consists of the states of all the unit parameters.

In this case study, we have three consistent situations, defined by the mappings:

- Scenario: Source S1 ➔ (TV: on, Source-selection: S1, Source: on)
- Scenario: Source S2 ➔ (TV: on, Source-selection: S2, Source: on)
- Scenario: Idle ➔ TV: off

Implementation: automation

The root cause of failure in operating using entertainment control is errors in device selection. In a scenario-driven design, the selection may be automated. The selection button is replaced by a software switch. In this case study, we have three consistent situations, defined by the mappings as above:

Scenario: Source S1 ➔ automation sequence

1. Select monitor, turn it on, select monitor source, set it to A
2. Select Source S1, turn is on
3. Provide feedback message: you are watching Source S1.

Scenario: Source S2 ➔ automation sequence

1. Select monitor, turn it on, select monitor source, set it to B
2. Select Source S2, turn is on
3. Provide feedback message: you are watching Source S2.

Scenario: Idle ➔ automation

1. Select monitor, turn it off

In normal operation, the situation is scenario driven. The human operator and the system are coordinated by the operational scenario.

The scenario should be implemented as a concrete system entity that the system should handle, ensuring that the situation is well defined. In the entertainment control case study, the implementation of the operational scenario is the scenario variable, with values: Source S1, Source S2, Idle.

Conclusions

Entertainment control incidents demonstrate the need for early detection of inconsistent situations. The article presents a rule-based model of the system operation, and a method for eliminating the risks of control errors. The method highlights the benefits of generic rules for associating the system situation with the scenarios.

The solution to the entertainment control problem may apply also to the other domains, such as home control, home computing and traditional appliances. The vision proposed here is that standards on integration engineering may include a chapter on when and how to apply the rules for setting and controlling entertainment systems. These rules may be specified in the unified architecture framework (UAF, Martin & O'Neil, 2021).

The vision

Entertainment control may be implemented by customized models based on generic rules such as those discussed in this article.

Interaction designers should pay attention to the technical, operational, functional, environmental, cognitive, and blackout factors, looking for ways to improve the control usability to enable seamless operation.

The quality of operation relies on rule definition. The generic rules developed in this study may be customized and applied to various kinds of interactive systems, in various domains, thus enabling reducing the costs of eliminating operational risks.

References

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