# TECHNICAL REPORT

## HCI design patterns for Space Structured Applications on PDA

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# 1. Introduction

Nowadays, mobile activities such as m-commerce [1, 2], m-learning [5], etc, are being increasingly adopted by people. For example, [3] estimate that 237 billion mobile terminal users have conducted m-commerce in 2002, generating revenues of more than u$s14 billions. Moreover the adoption of customer-oriented mobile commerce initiatives is accessible to all firms (large or small) and is foreseen as the "next step" of e-commerce [4]. On the other hand, m-learning can be seen as a "next step" of e-learning as suggested by [5].

New mobile activities are being explored and one of them is to support Augmented and Immersive Reality (A&IR) features on physical spaces. Public spaces as shops, libraries, museums, etc do not have enough information available for public about objects exposed there; at least when people are visiting such spaces. For example, in a museum; usually most of information about pieces is not available to visitors.

Main reasons are physical space constraints and information media restriction to text and image only; because audio and videos should be presented to all public at the same time (people must be "synchronized" at the beginning of reproduction).

Many applications and studies have been carried out to expand information availability on these kinds of spaces to improve user experience.

As an example of information availability expansion; web technologies offered new opportunities to open up the walls of museums to the world [6], an opinion shared by several researchers in the field [7, 8, 9 and 10]. Examples of this view were: The Museum Educational Site Licensing Project, the Art Museum Image Consortium[1], the Virtual Museum of Canada[2], Minneapolis Institute of Arts[3] and the Online Archive of California[4].

Currently, a new step in communication and mobile technology seem to be leading the future of art galleries and museums applications to mobile applications. An example is exposed in [11] at The Cutlery Museum in Albacete, know as MCA in Spain. The MCA is an emblematic institution of the city that is currently using an electronic device to guide visitor through the museum.

A study involving a comparative evaluation of different platforms for augmenting museums and art galleries was presented as part of [12]. Several prototypes of an application were developed for three different devices: a HMD[5], a PDA and a Tablet. As a result PDA tended to out-perform the other prototypes.

So, it seems that PDA or Smartphones, will be the target of this kind of applications in the future. However, these devices have several limitations. For example, one obvious constraint on PDAs is the modest amount of real space available on a screen. As a result, it is essential to simplify the User Interface (UI) as much as possible to ensure UI readability without sacrificing usability.

The situation stated before is common to all applications that share described features, so it is important to define generic solutions to solve these problems because that can be applied recurrently.

1 http://www.amn.org/AMICO/
2 http://www.virtualmuseum.ca/
3 http://artsmia.org/directories/
4 http://www.oac.cdlib.org/
5 Head Mounted Displays

To address the situation stated before, design patterns [13] seem to be an appropriate tool to provide generic solutions that enable designer to solve specific problems.

This paper is organised as follows. First, a definition of Space Structured Applications, applications that match described requirements, will be set to establish an environment were patterns will be applied. Then patterns characteristics and categories will be described. Later, a list of patterns organized in described categories will be shown according to characteristics and categories described before. Once patterns were described, they will be applied to a concrete application. And finally, conclusion and future work will be presented.

# 2. Space Structured Applications

The implementation and evaluation of [11] lead us to implement a new application to improve HCI. This time, our intent was not only focused on HCI improvement, but also to embrace applications that share the same characteristics and provides generic solutions to problems that are common to all these applications.

To fulfil our purpose, we characterized these applications as Space Structured Applications (SSAs). A SSA models physical spaces (buildings, floors, rooms, etc) that contain extra information about objects dwelling in these places. So, users can use this metaphor to browse information belonging to a physical object or space. They can also look for information and locate it physically.

SSA may be considered as augmented and Inmersive Reality (A&IR) applications that improves information availability. Information that is not available for any reason, physical space limitations or simply because it is not intended for all people, can be displayed according to user choice.

Objects that are not physically available may be so, virtually. Having an object virtually into a SSA provides a physical context to the object and vice versa, providing contextualized information or context for information that leads to a richer user experience. Even more, an object may be virtually available and contextualized into more than one space.

An example of this situation may be stated in a museum. Pieces are submitted to a service period and are not available to public during this period. However, a photo may be instead of the piece in the meantime, and information accessed through PDA as the piece is there. Another example, where context for pieces is given is a SSA that implements a museum where Greek pieces are show in a room. These pieces belong to the Parthenon, so virtualizations of Parthenon may be provided to users as part of contextual information about pieces.

A key issue of SSA is the fact that the physical space is part of the application and physical position of objects is used to address extra information about it.

As mentioned at previous section, physical spaces modelled by SSA embrace museums, libraries, shopping and so on. Most of SSAs are public spaces, so accessibility becomes a key issue in these applications.

The following list summarizes key aspects to take into account that should be covered by SSAs:

1. User *position and orientation* is essential keep virtual and physical spaces synchronized. To achieve these feelings a close relationship between SSA navigation and physical space should be created.
2. Most of SSA users are visitors, so *effort to browse information should be minimized*. Visitors usually carries bags and other burdens and they have only one hand free, so devices running this kind of applications should be used by one hand only.
3. SSA may be used to *guide people* through the physical space instead of just browsing it; taking an active interaction role too. Context information and users interest may be used to provide a balanced amount of information to the user.
4. Accessibility is a key issue to board because SSA may help disabled people to interact with their environment.

*SSA may also be called **m-space** applications, because they provide a virtual view of a physical space in a mobile device.*

# 3. HCI Design Patterns

Based on [13] design patterns[6] of mobile interaction [14] were defined. This proposal restricts patterns appliance to SSA only. Besides, from Roth pattern class point of view this proposal is restricted to UserInterface patterns only. So, subclasses or categories of UserInterface patterns will be defined.

To describe patterns, established description formats [13] will be used. So to describe a pattern the following sections will be used: Name, Synopsis, Context, Forces, Solution, Consequences, Schematic Description and Related Patterns.

As [14], Implementation section has been replaced. In this case, our proposal includes Schematic Description instead of Example. Classes were replaced by Category too.

So, the collection of HCI design patterns is organized into four categories; each category focuses on specific issues of SSAs:

- *Location*: This category introduces HCI patterns to help users to get oriented within the physical space. These patterns improve virtual/physical synchronization of space in order to locate users into the space.
- *Routing*: Design patterns on this category are used to model routes and paths that users may follow. These paths can be used to guide users through physical space based on user or institution preferences. For example, special characteristics of objects or places.
- *Layout*: Layout patterns were introduced to organize space structured applications. Screen resolution on mobile devices are restricted, information to be displayed is increased due to virtual / physical space relationship and objects extra information. So it is important to know how to layout and present this information.
- *Accessibility*: One of the main objectives of this kind of applications is to provide disabled people with the possibility to access these spaces. So accessibility category is used to group patterns that can be applied to improve application access to disabled people.

Main reason patterns are grouped is the need for quickly identify a set of patterns that address problems related to SSA described aspects. The following list describes aspects covered by each category:

1. As SSAs are based on a space metaphor, user position and orientation is essential to keep awareness of virtual information and real object perception. Patterns grouped in Location category will be used to cope with these features.
2. SSAs are intended to be used by users that are physically visiting the space, so the effort to browse and get information from PDA device should be minimized. Layout pattern category meets these characteristics.
3. SSAs can also be used to guide a user across the space, providing contextual information related to user interest. This functionality is addressed to Routing pattern category.
4. As mentioned before, SSA application fields lays on public spaces. Accessibility is a key feature of this kind of applications. So Accessibility patterns can be used to improve this issue.

## *3.1. Location HCI patterns*

Patterns grouped in this category are used to orientate and position users in the physical space. These patterns tends to simulate physical space as similar as possible to real space in order to create a virtual environment that could be easily matched to the physical one.

Most of these patterns are based on the fact that spaces are composed hieratically, so paths can be built to identify them uniquely.

### Address (*aka* You are here)

**Synopsis:** A user tries to identify selected space somehow. Usually, public spaces are identified by names; so they should be supplied to the user. Addresses pattern is widely used on Web.

**Context:** Suppose that a user has to tell another user where is he/she. Space identification is useful to perceive how far a user is from a point in large spaces. Large spaces are divided into sub-spaces; for instance, different buildings, floors and rooms. So any user can be aware of distances just by relating two addresses. It means that if two rooms are in the same floor are “nearer” that if they were in two different buildings.

**Forces:** Large and complex spaces may disorientate users, and may loose conscience of space distance. By applying this technique, users may acquire a level of space awareness enough to keep themselves aware of distances.

**Solution:** Adding an address bar on top or bottom of screen where different levels of spaces are expressed. For instance: MAIN BUILDING->FIRST FLOOR->CENTRAL HALL.

On long space identifications, text may be shown as a marquee.

**Consequences:** User keeps track of actual position and can identify this position to physical space. Some disadvantages of this approach are:

- Reduction of a restricted mobile device screen.
- When using Vertical Layout (see Layout HCI patterns) this approach may get “out of place” into the screen

**Schematic Description:**

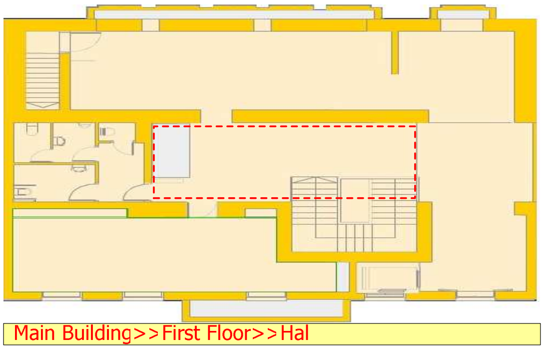


Figure 1

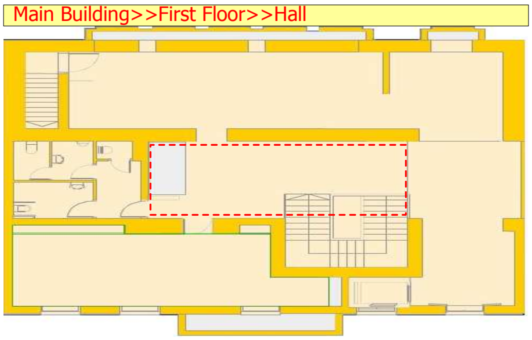


Figure 2

**Related Patterns:** Layout Patterns. + Signs

## Multi-Layer Map

**Synopsis:** Sometimes users need a physical position of a space. As mentioned above there is a space hierarchy so a physical space position can be determined by the space position of each level.
**Context:** Sometimes users do not know exactly what they are looking for, so they just start browsing. In order to get the physical location of an object, a Multi-Layer Map is used to supply the information of the object physical location.
**Forces:** SSAs are usually used in two ways, first to locate a user o a piece or to look for a piece into the space.
**Solution:** Adding an address bar on top or bottom of screen where users can see the space they are interested in across different space levels. Level labelling is useful to avoid user deduce it.
**Consequences:** Users can be aware of his/her physical position or selected object physical position virtually. It also can be used in a vertical or horizontal layout; as show in Figure 3 and Figure 4.
Some disadvantages of this approach are:

- Reduction of a restricted mobile device screen. This solution needs more screen space than **Address** solution.

**Schematic Description:**

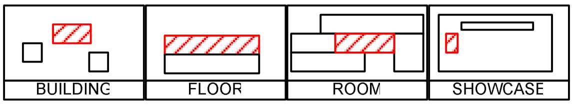


Figure 3: Horizontal Layout

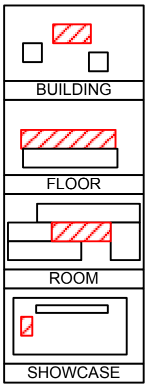


Figure 4: Vertical Layout

**Related Patterns:** It can be used jointly with **Address**.

## Door at back (aka Exit)

**Synopsis:** This pattern helps users to get oriented when a space transition occurs. A space transition happens when a users moves virtually and physically from one space to another; for instance form a room to another.
**Context:** Most of SSAs are based on a map, a typical way to represent spaces. To improve user virtual-physical synchronization, users should know their position by making the less effort as possible. This pattern tends to reduce the gap time that a user needs to get oriented after a space context change.
**Forces:** Users may lose orientation between space transitions.

**Solution:** Solution is carried out in two steps. First step, a map may be automatically oriented according to the door a user may have used to get into a space. Usually, these doors may be deduced, because probably it is the only one; or is deduced from previous state. Door position should always point to the user (see Figure 5 and Figure 6). Second step just adds an arrow pointing into the room a user may have entered, to provide directional information.
**Consequences:** Users becomes aware of their orientation/position virtually and physically. Map orientation may be combined into a layout change depending on map shape.
As a disadvantage, a map is needed.
**Schematic Description:**

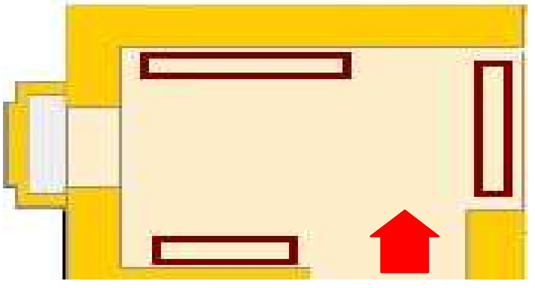

Figure 5: Horizontal Map position

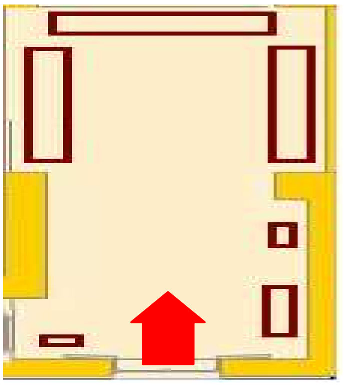

Figure 6: Vertical Map position

**Related Patterns:** It can be used jointly with **Address**. It also may be influenced by layout patterns.

## Signs

**Synopsis:** This pattern helps users to get oriented when a user spends a long a time into a space and get lost there. A sign is used to synchronize virtual and physical space.
**Context:** Most of SSAs are based on a map, a typical way to represent spaces. To improve user virtual-physical synchronization, users should know their position by making the less effort as possible. This pattern tends to reduce the gap time that a user needs to get oriented after spending a long time inside a space.
**Forces:** Users may lose orientation when spends some time into the same space. This particularly happens when the space the user is visiting is large and its view is homogeneous.
**Solution:** In order to synchronize virtual and physical space a sign that is visible in both spaces helps user to synchronize both views.
**Consequences:** Users becomes aware of their orientation/position virtually and physically. Combined to **Door at back** provides a really powerful orientation tool.
As a disadvantage, a map is needed.
**Schematic Description:**

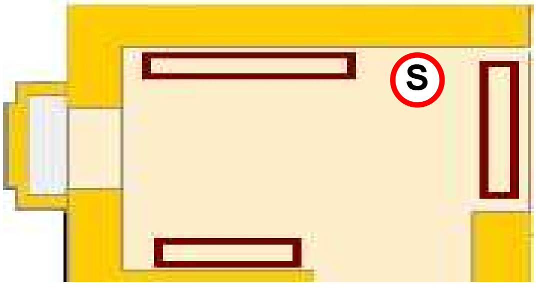


Figure 7: Horizontal Map position

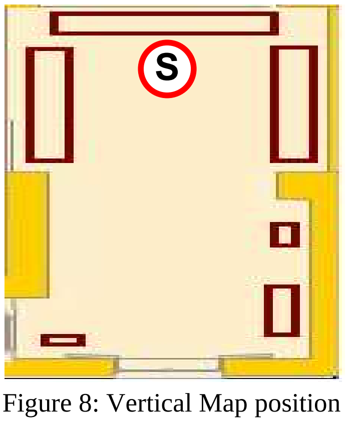


Figure 8: Vertical Map position

**Related Patterns:** It can be used jointly with **Address** and **Door at back**.

## 3.3. Layout HCI patterns

This patterns deals with mobile devices screen restrictions. In order to take advantage of screen these patterns explain how to exploit screen dimensions according to data shape.

Layout patterns may be seen as a way to adapt screen to data, so this activity is dynamic and it should be carefully designed to avoid user disorientation (see Location patterns).

### Landscape

**Synopsis:** This pattern proposes to use PDA in Landscape direction.
**Context:** Media as photos or movies are usually displayed in landscape; so the natural way to display this information is in landscape. Besides, using PDA in landscape position allows users to hold the device and access cursor controls using one hand only.
**Forces:** Public SSAs are usually accessed by people that are carrying baggage. As a consequence, they have one hand free at a time to use the electronic device. So, it is necessary to introduce a way to manipulate mobile devices with one hand only.
**Solution:** Application design based on a landscape position.
**Consequences:** Users can use device with one hand only. However, controls and application orientation must be synchronized for right or left handed people.
It means that a horizontal mirroring is needed to synchronize screen. Up and down button should be swapped; and left and right should too.
**Schematic Description: …**
**Related Patterns: …**

### Vertical – Horizontal layout

**Synopsis:** Modify application layout according to information to display. Application view contains two types of data: primary or main data and secondary data. According to primary information shape, mobile device interface adapts application UI layout.
**Context:** Data, as maps or photos, may be displayed in portrait or landscape. To optimize screen visualization secondary data is adapted to fit the screen according to best fit primary data.
**Forces:** Media visualization may differ on information to be displayed.
**Solution:** Adjust primary data information to best fit screen shape. Then change secondary data information shape to fit available space.
**Consequences:** Primary data information is optimized to fit screen and secondary information is displayed on available space.
Secondary information may not be displayed correctly or might be avoided.
**Schematic Description:**

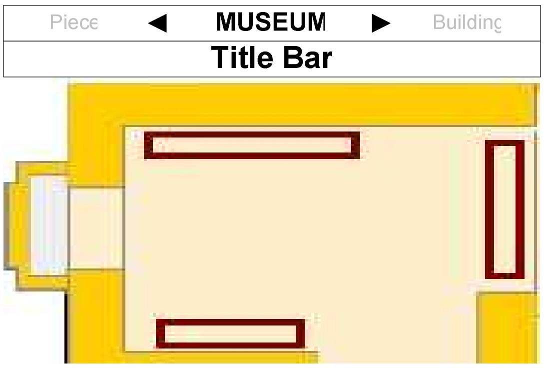

Figure 8: Horizontal Layout

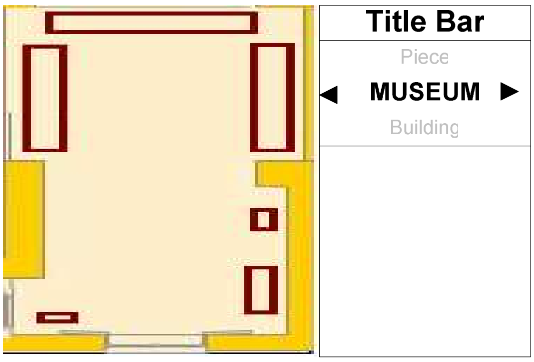

Figure 9: Vertical Layout

**Related Patterns: …**

### *Layout transition*

**Synopsis:** Show layout change transition.
**Context:** Screen layout changes according to information to be displayed.
**Forces:** Users see a change that does not explicitly performed, so they feel that they are not “controlling” the application.

**Solution:** A smooth animation that provides to users feedback about application new layout and information distribution.
**Consequences:** User gets feedback about interface changes**.** However, it introduces a delay into HCI activities.
**Schematic Description: -**
**Related Patterns: Vertical – Horizontal Layout.**

## *3.2. Routing HCI patterns*

This pattern category groups patters that are related to space navigation. They provide awareness about control actions. These patterns also provide ways to go through space considering user or expert preferences.

### Free will Navigation (aka left-right or up-down)

**Synopsis:** This pattern intent is the provision of a method to access spaces at any level through application using cursor keys only.
**Context:** Public SSAs are usually accessed by people that are carrying baggage. As a consequence, they have one hand free at a time to use the electronic device.
**Forces:** It is necessary to introduce a way to manipulate mobile devices with one hand only in landscape position.
**Solution:** Is achieved in two ways:

1. Control navigation is ruled by cursor buttons:
    a. Left – Right: To navigate across space levels (inter-level). Right arrow cursor button goes one level into selected space; while Left arrow cursor button goes one level up.
    b. Up – down: To navigate across same level spaces (intra-level). Selects a subspace into the same space. Up and Down cursors selects spaces labelled with corresponding arrows.
2. Labelling actions with arrows representing cursor button on screen to provide user feedback about actions.

**Consequences:** User is aware of navigation destination using cursor keys. If proposed control combination is accepted as a standard, this combination will be “the natural combination” for navigating across SSAs.
Unfortunately labels may obscure map.
**Schematic Description:**

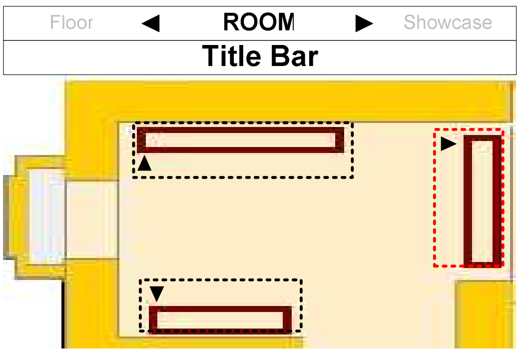

**Figure 9: Room View**

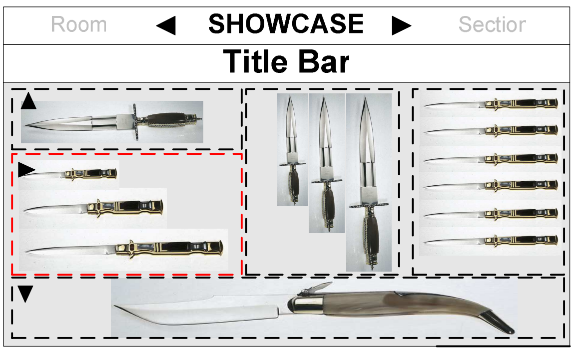

**Figure 10: Showcase View**

Figure 9 shows a room where right showcase is selected. Pressing up cursor, top showcase is selected. Pressing down cursor, bottom showcase is selected. If right cursor is pressed, the screen depicted in Figure 10 is shown. However, if left cursor is pressed, the floor map is displayed.
**Related Patterns: Landscape Layout.**
**Remarks:** We propose this solution as a standard to manipulate SSAs.

### Routes

**Synopsis:** Routes pattern provides custom routes to focus a visit on user interest.
**Context:** Large spaces are difficult to explore, because they contain huge amount of data and information that is not manageable by users. Even though, perhaps the whole information is not interesting to a visitor because he/she is interesting in only part of the information.

**Forces:** Large spaces and user interest.
**Solution:** A bi-panel view implementation is used to cope with this problem:

1. Route selection panel: It allows user to select a route of a set. Swapping between Route selection panel and Map is usually assigned to a button that is not related to cursor buttons. When a user selects a route, up and down cursor buttons selects next and previous spaces in the route instead of subspaces belonging to the same space. A special route called Free is used to avoid using routes.
2. Map panel: It shows actual map. Navigation control is the same used in **Free Will Navigation**.

A key, in Schematic Description assigned to is used to switch between views.
**Consequences:** A visit can be focused on user interests. It also provides an easy way to look for objects or spaces in a close range search. Device operation is simplified; two controls are needed: **Previous and Next.**
**Schematic Description:**

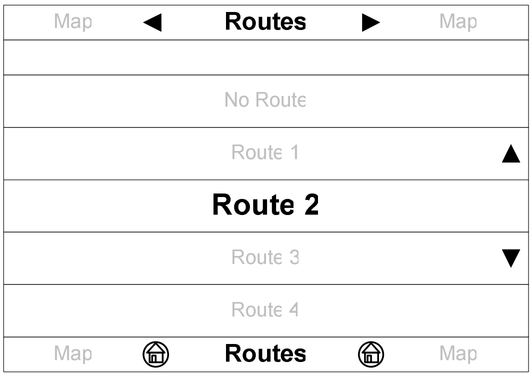

**Figure 11: Route Selection Panel**

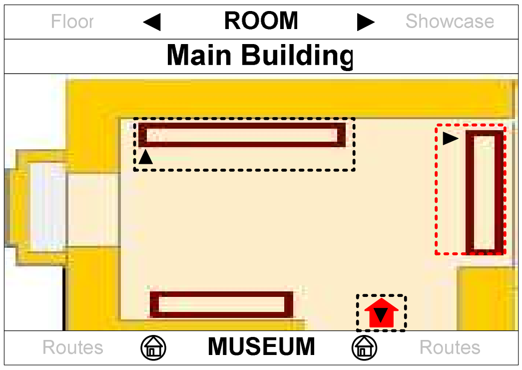

**Figure 12: Map Panel**

**Related Patterns: Free Will Navigation.**

## *3.4. Accessibility HCI patterns*

### Space audio perception

**Synopsis:** A voice tells the user which space has selected
**Context:** Blind people is capable of identify cursor keys, so they are able to navigate across any SSA.
**Forces:** Blind people cannot see selection or environments from screen
**Solution:** Add voice awareness to SSA.
**Consequences:** Blind people can enjoy the application and get profit of it.
**Schematic Description: -**
**Related Patterns: Free Will Navigation.**

### Right – Left handed users

**Synopsis:** This pattern purpose is to adapt a SSA application that is designed using the Landscape pattern to be used by right-left handed people.
**Context:** Usually people do not have the same skills on both hands. So, if an application that should be used with one hand only, it is logical that the hand used to perform operations be the skilled one.
**Forces:** Right – Left handed users
**Solution:** Solution lays on two issues:

1. Mirroring screen horizontally
2. Change cursor control behaviour (Up - Down) (Left - Right)

**Consequences:** Accessibility is improved, and the system can be used by people more efficiently.
**Schematic Description: -**
**Related Patterns: Landscape.**

### Zoom

**Synopsis:** The aim of this pattern is the provision of controls to change font size easily when users are reading documents.
**Context:** Elder people usually have problems to read documents from portable devices.

**Forces:** Improve accessibility for elder or disabled people.
**Solution:** When a text is being shown, it is wrapped and cursor keys to left and right are user to increase – decrease font size. While up and down are used to scroll text.
**Consequences:** Accessibility is improved, and the system can be used by people more efficiently.
**Schematic Description: -**
**Related Patterns: -**

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