

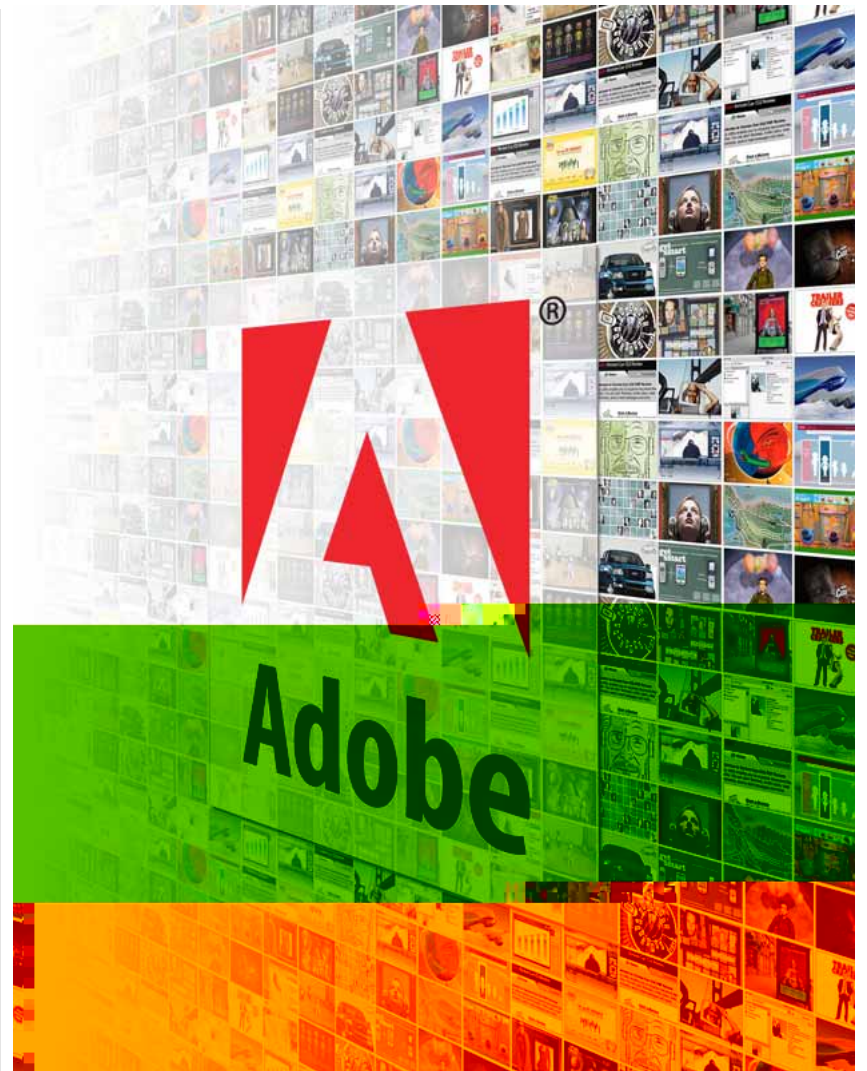
Science of 'Shrink Wrap'

*A Look Inside Adobe®
Photoshop®*

Sean Parent

**Principal Scientist & Manager
Adobe® Software Technology Lab**

January 18th, 2008



Adobe Today

Worldwide Offices



Corporate Headquarters – San Jose, California



Key Statistics

FY2007

\$3.16B

Years in Business

25

Employees

6,000+

Photoshop History

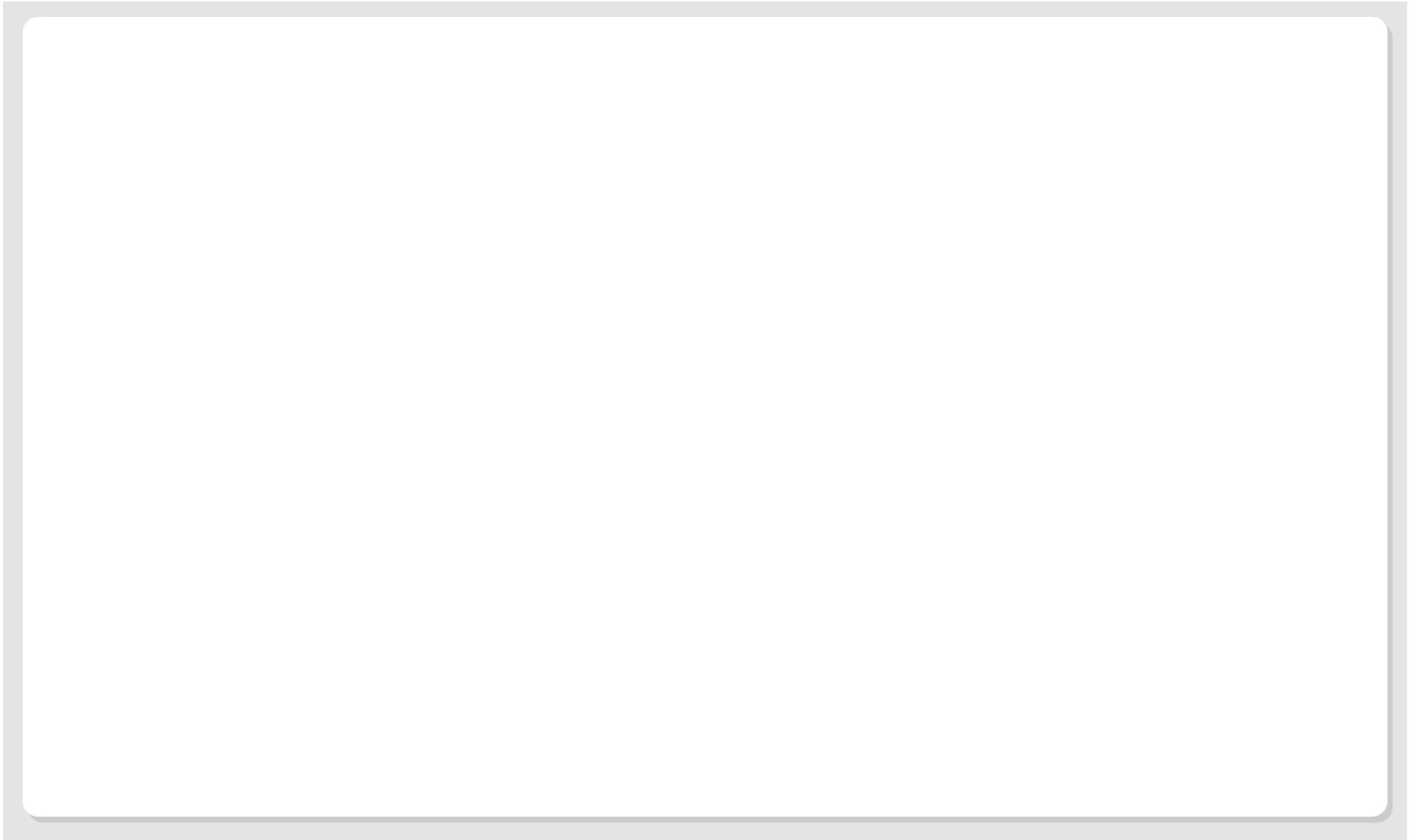
- **1987: Started by Thomas Knoll**
- **1990: 1.0 Shipped by Adobe**
- **1991: 2.0 Clipping Path**
- **1993: 2.5 First Version on Windows**
- **1994: 3.0 Layers**
- **1996: 4.0 Actions & Adjustment Layers**
- **1998: 5.0 History & Color Management**
- **1999: 5.5 Web Development**
- **2000: 6.0 Typography**
- **2002: 7.0 Camera RAW, Healing Brush, Natural Painting**
- **2003: CS Lens Blur, Color Match, Shadow/Highlight**
- **2005: CS2 High Dynamic Range Imaging, Smart Objects, Lens Correction**
- **2007: CS3 Smart Filters, Improved Compositing Tools**

Demo

Photoshop Code

- **100% C++ since Photoshop 2.5**
- **Statistics for Photoshop CS3 (Core):**
 - **Lines:** 1,467,150
 - **New Lines:** 107,129
 - **Engineers:** 30
 - **Develop Cycle:** 24 months
- **Image Processing Code: $\approx 15\%$**

Q: Where is the other 85%?



Q: Where is the other 85%?

- **A: The User Interface**

The User Interface

- **Definition: A User Interface (UI) is a system for assisting a user in selecting a function and providing a valid set of parameters to the function.**
- **Definition: A Graphical User Interface (GUI) is a visual and interactive UI.**

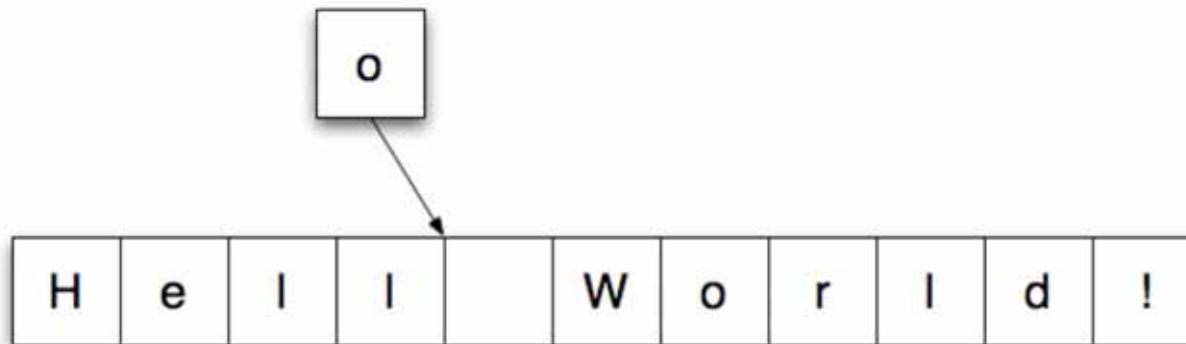
Example - Text Editor

- **Document Model**

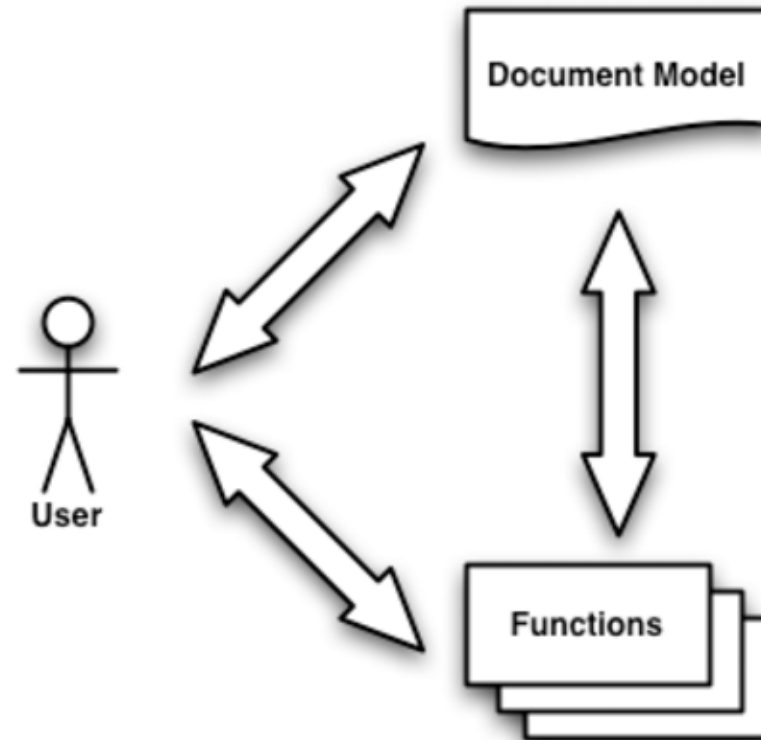
- sequence of characters

- **Functions**

- insert (sequence, location, character)
 - **Precondition: location must be within the sequence.**
 - erase (sequence, range)
 - **Precondition: range must be within sequence.**



Design Space



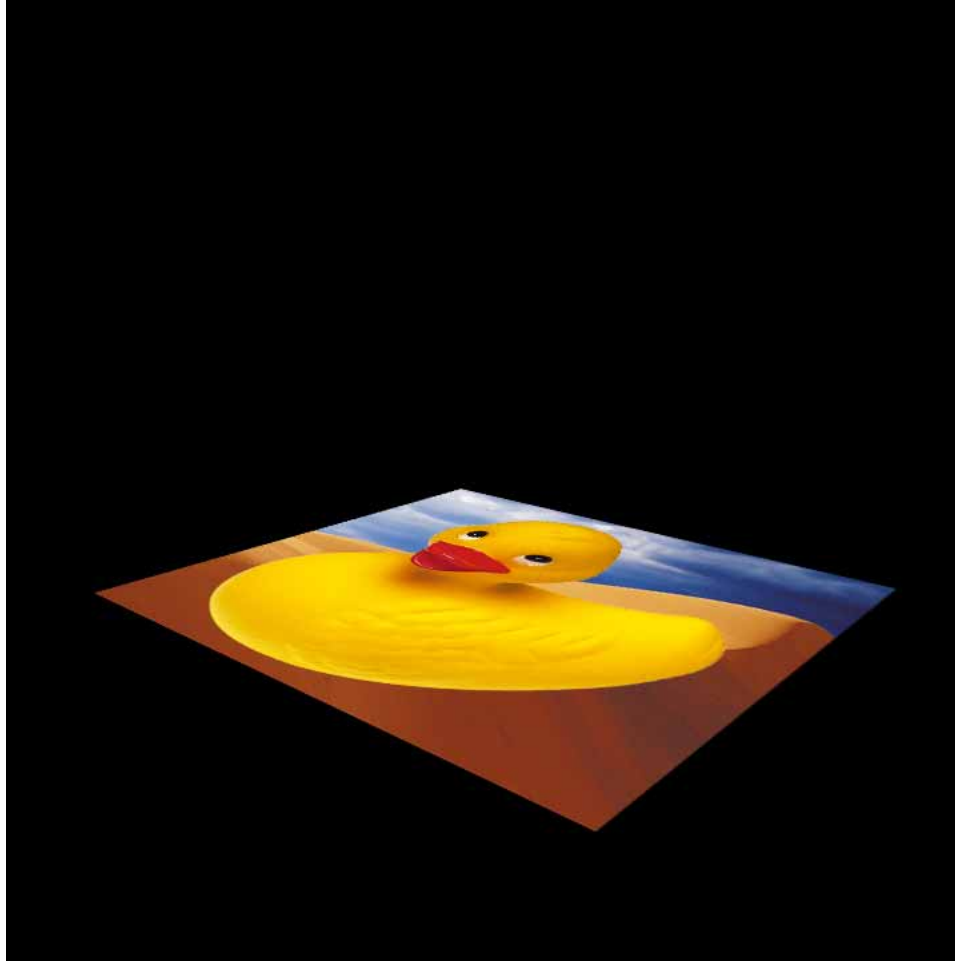
Design Space

- **User requirements determine desired functions and model**
- ***Assistance* drives choice of algorithms for functions**
- **Choice of algorithms constrains choice of data structures**
- **Data structures and algorithms constrain available functions**

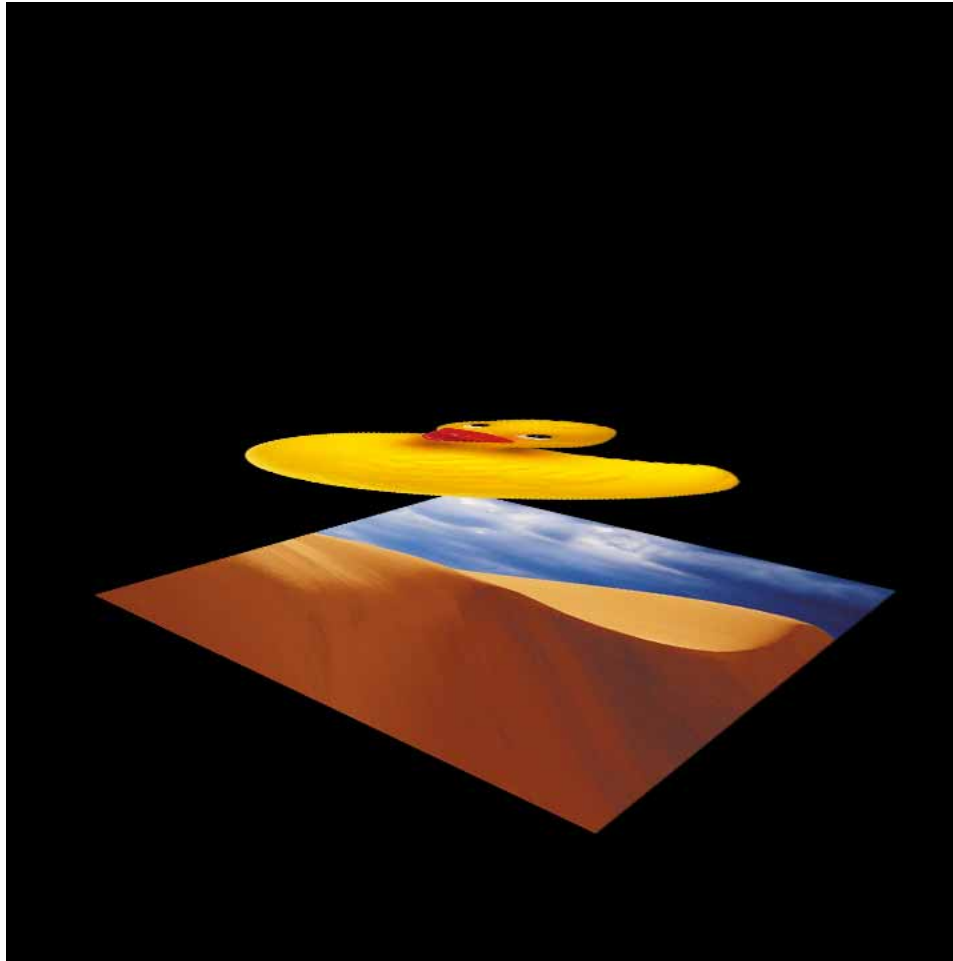
Photoshop Document Model



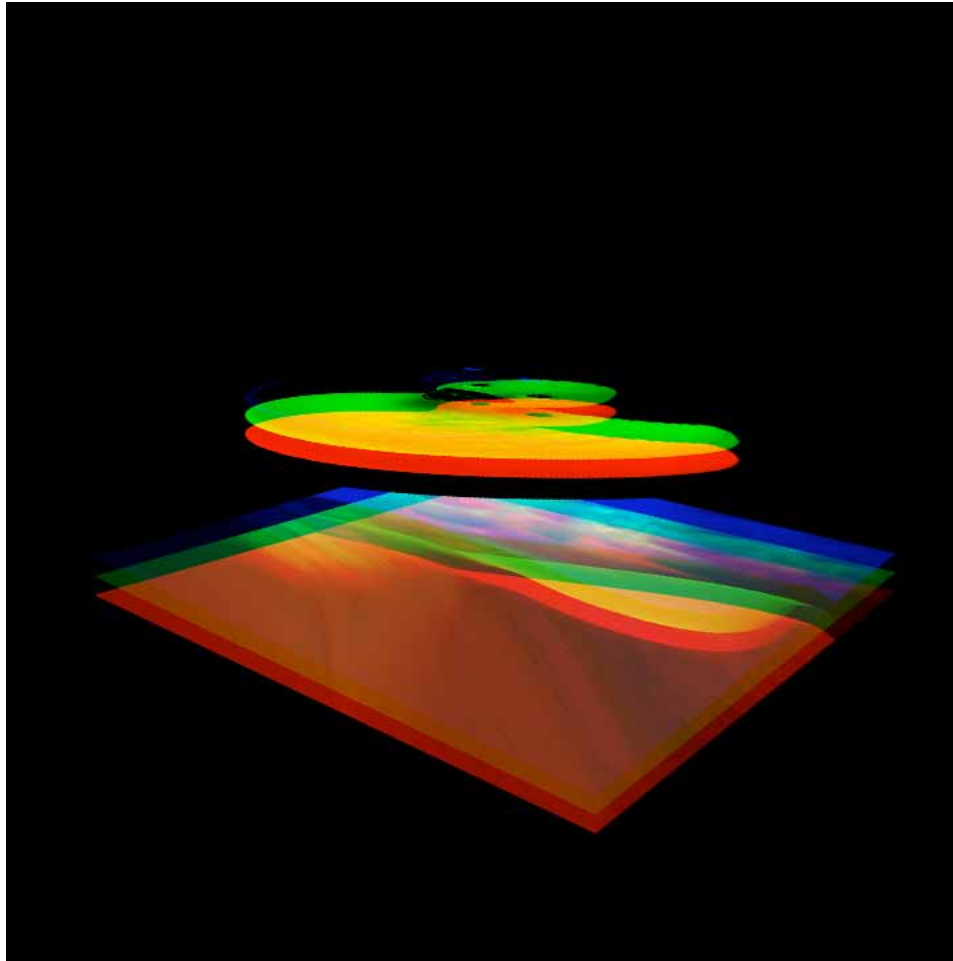
Photoshop Document Model



Photoshop Document Model



Photoshop Document Model



Photoshop Functions

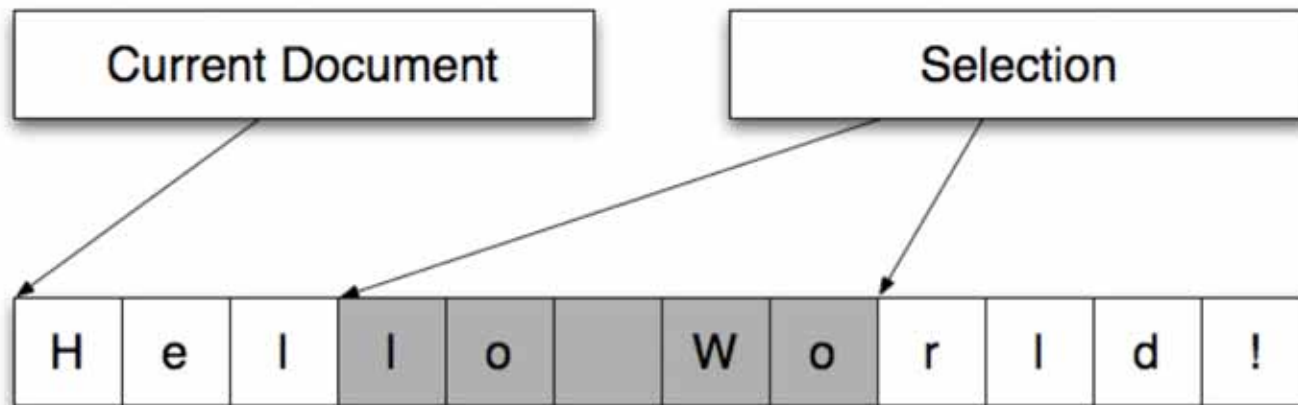
- **make_layer(), gaussian_blur(), transform_image()... and several hundred more.**

Providing Context

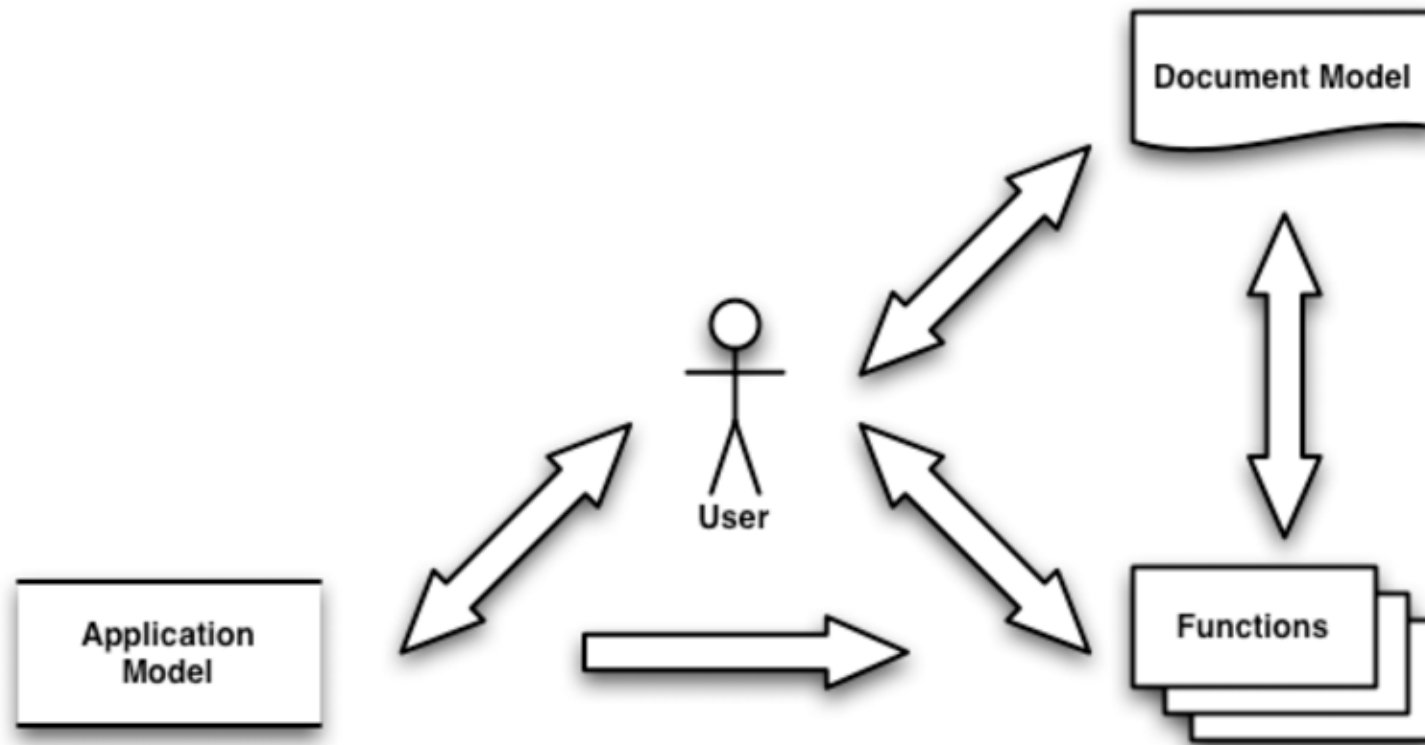
- **Often there is a “subject” which is being operated upon. Provide state to remember the current subject.**
- **The subject is simply one or more of the parameters to some of the available functions.**
- **Context can also contain the “current” function which is usually presented as a tool.**

Example - Text Editor

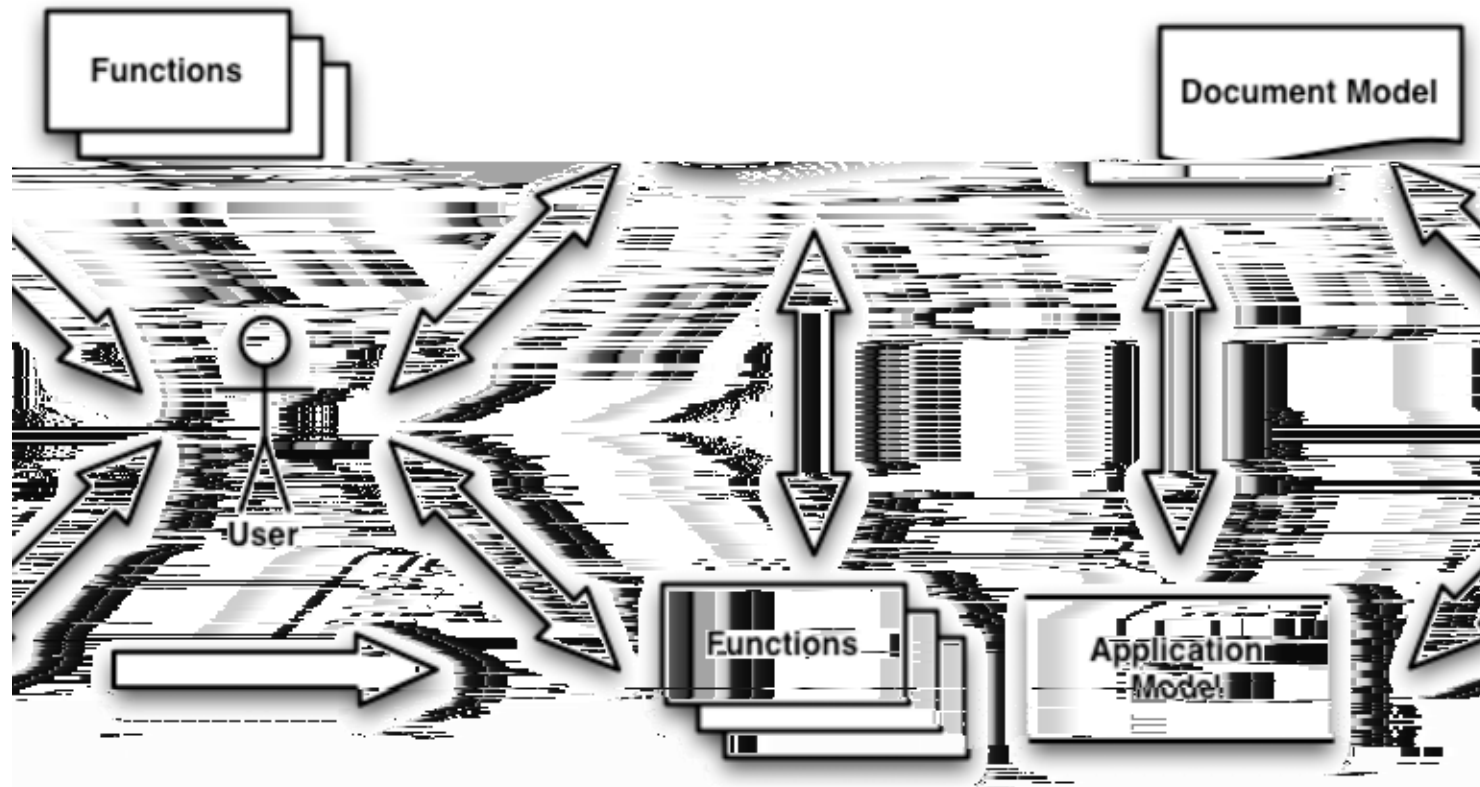
- **Context**
 - **Current Document**
 - **Provides destination**
 - **Selection**
 - **Provides a range; an empty range denotes a location**



Design Space



Design Space



Photoshop Context

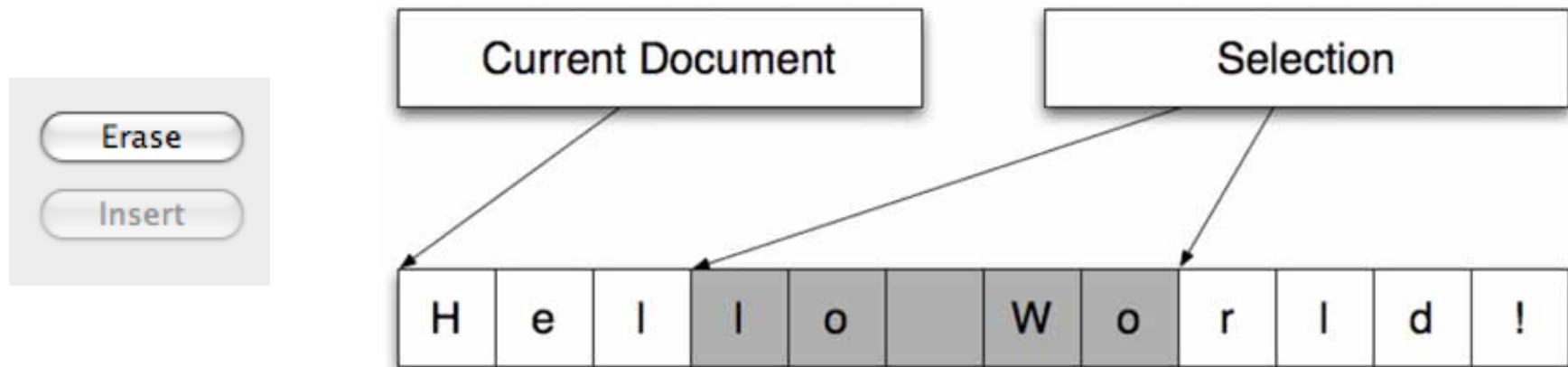
- **Sequence of Documents**
- **Current Document**
 - **Current Layer**
 - **Current Channel**
- **Current Tool**

Constraining Input

- **Only allow the user to select from valid options.**
 - **Functions can only be chosen if their preconditions can be satisfied by the subject.**
 - **Parameter values can only be set if they satisfy preconditions and currently contribute to the result.**

Example - Text Editor

- **The selection is defaulted to the beginning of the current document. The selection can only be changed to be valid within the document.**
- **An “Erase” command is enabled if there is a current document and a non-empty selection.**
- **An “Insert” command is enabled if there is a current document and an empty selection (note that location can be assumed to be valid).**



Constraints in Photoshop

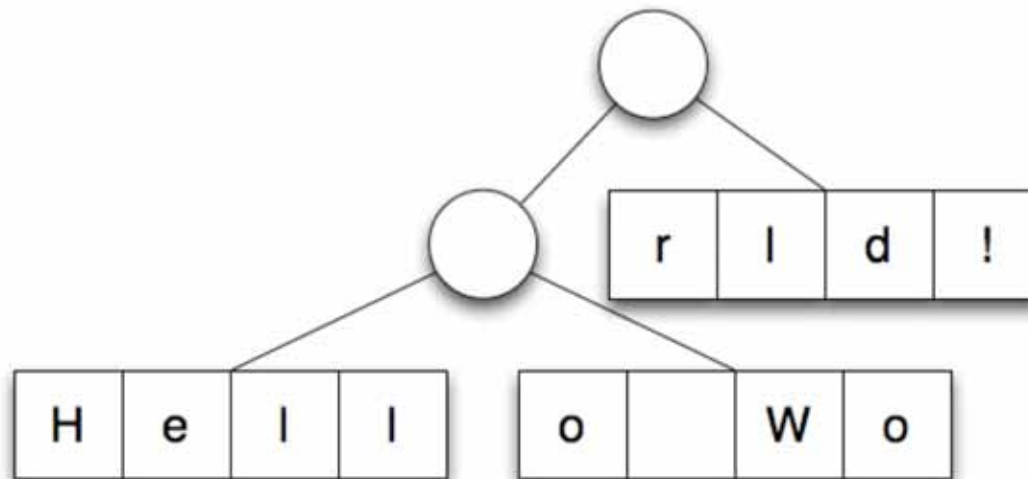
- **Commands can be enabled or disabled based on the current subject, or any attribute of the subject. For example, color space, color depth, number of channels**
- **Dialogs are a form of constraining the interface by focusing on the parameters to a single function**
- **Widgets may be disabled based on validity or potential contribution**

Interactive Assistance

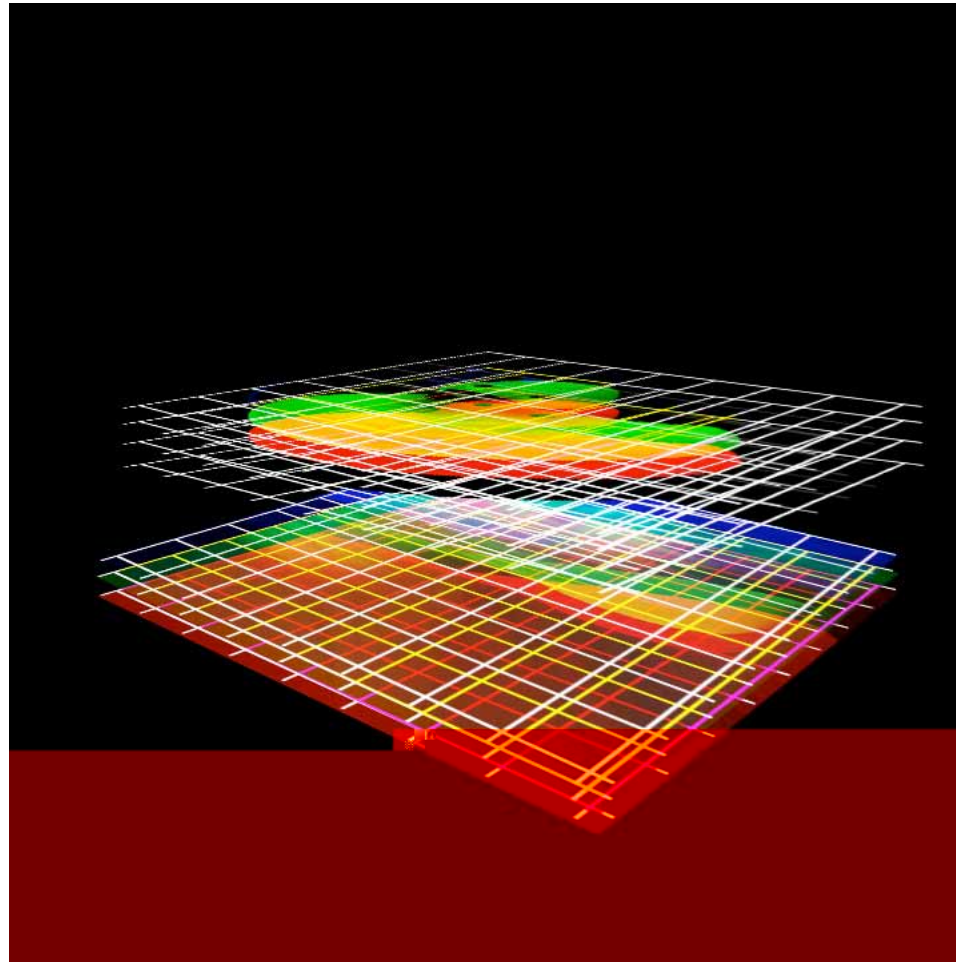
- **Tracking:** $\approx 1/30 \text{ s}$
- **Registration:** $\approx 1/5 \text{ s}$
- **Confirmation:** $\approx 1 \text{ s}$

Example - Text Editor

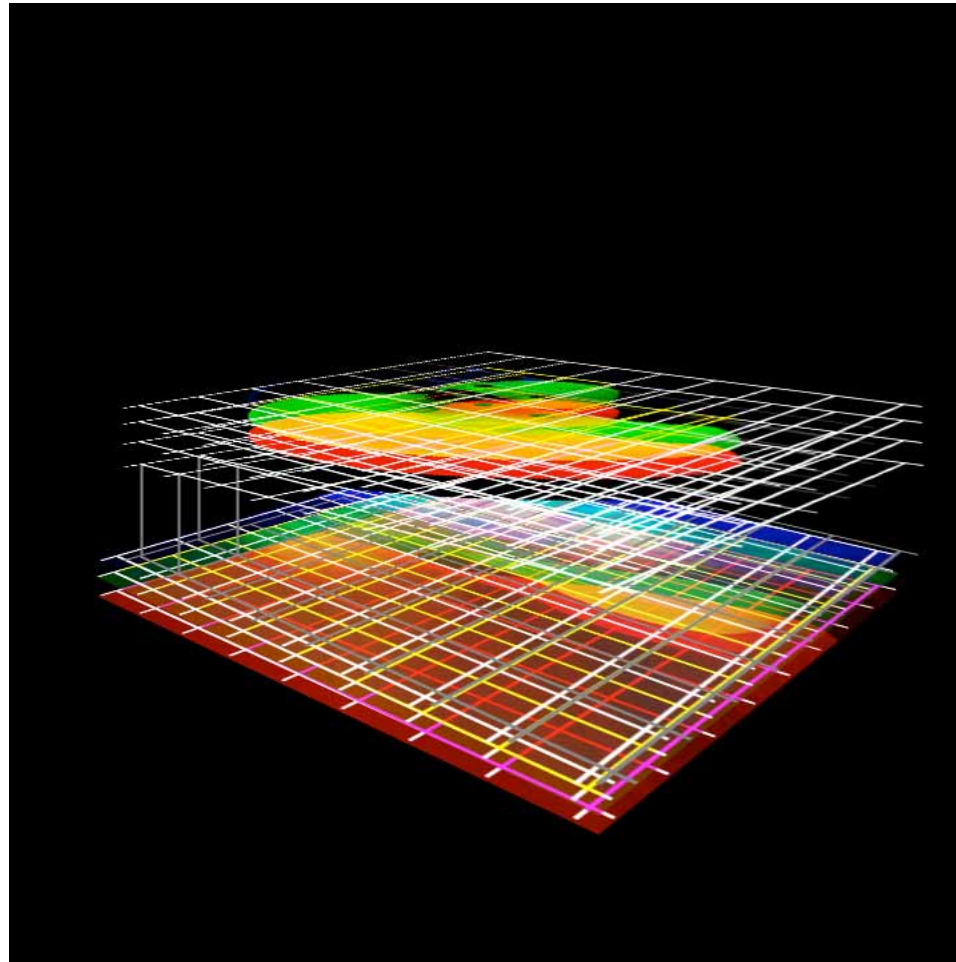
- **Need to be able to set the selection in “constant” time**
 - This would imply a vector data structure
- **Also need constant time insert and erase**
 - This would imply a list data structure
- **Solution: a more complex data structure such as a rope**



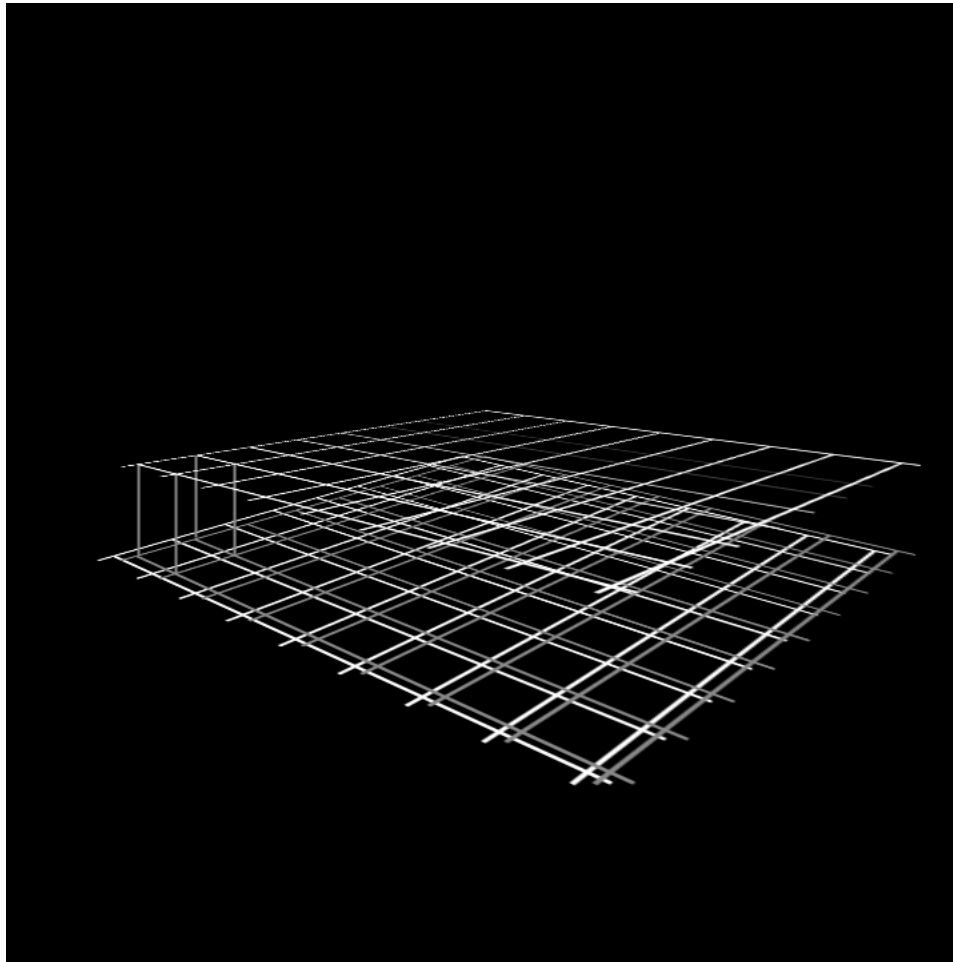
Tiles



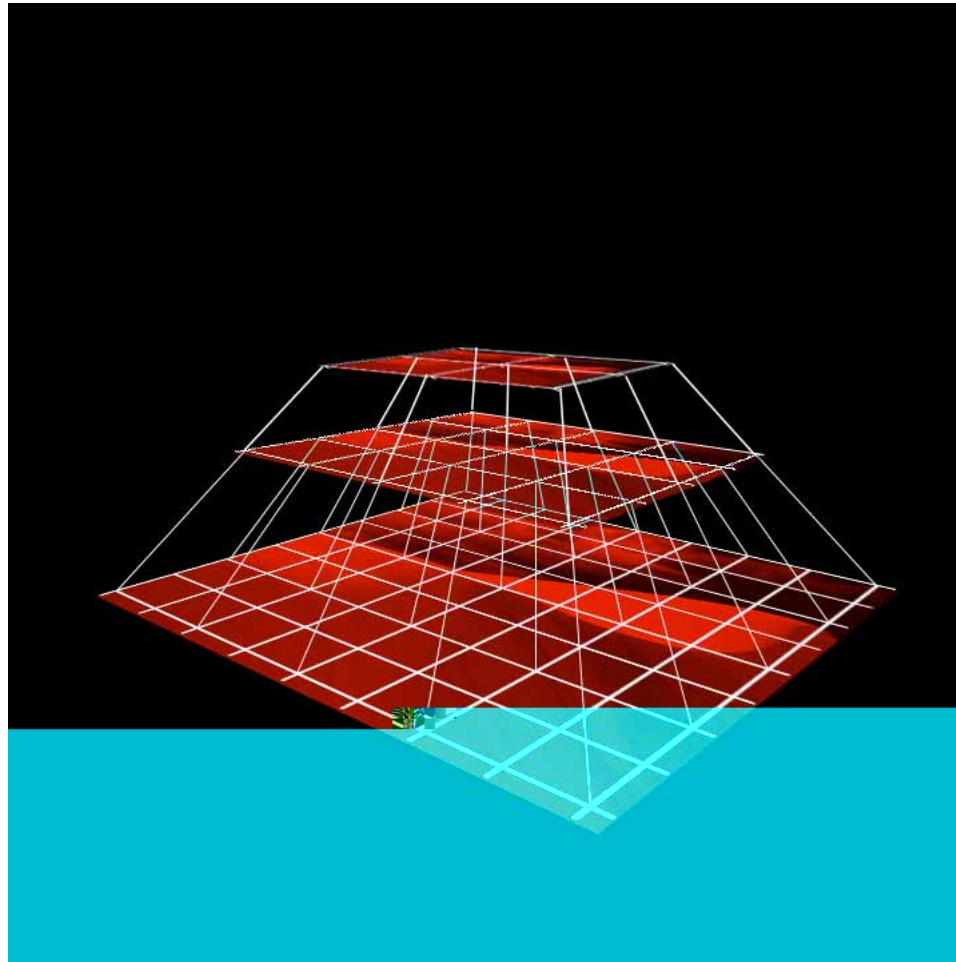
Tile Alignment



Tile Alignment



MIP Mapping

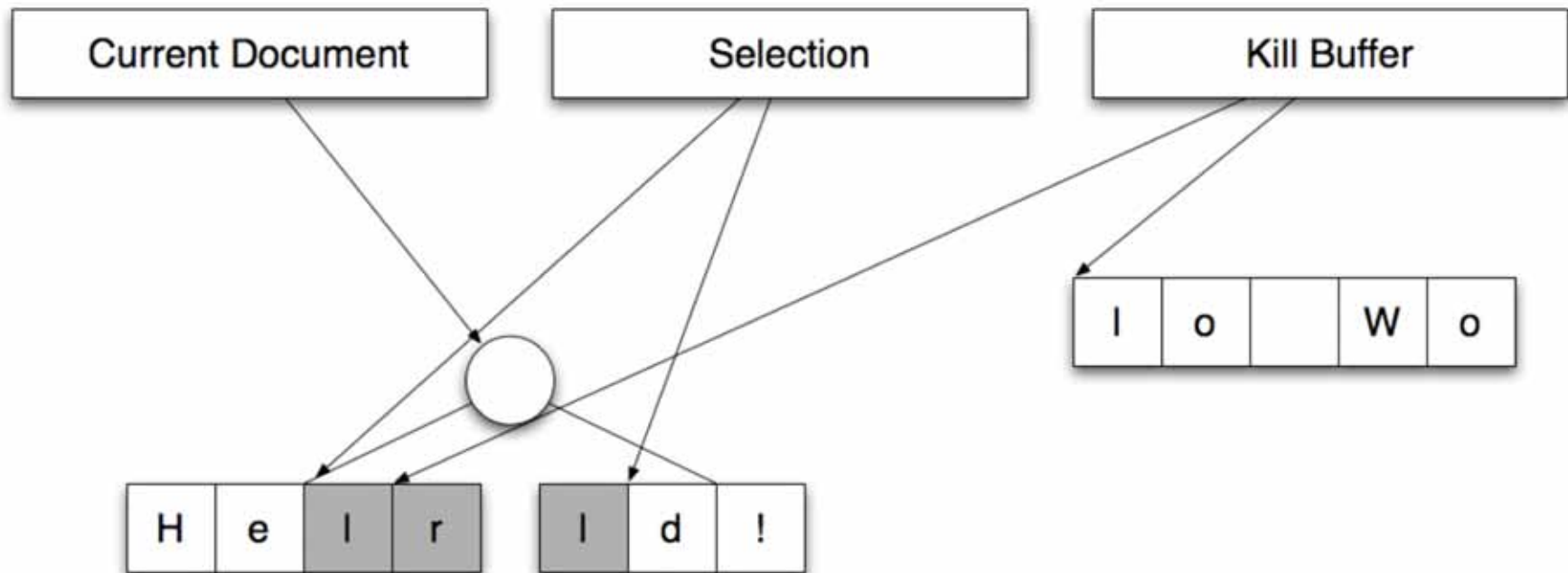


Prediction

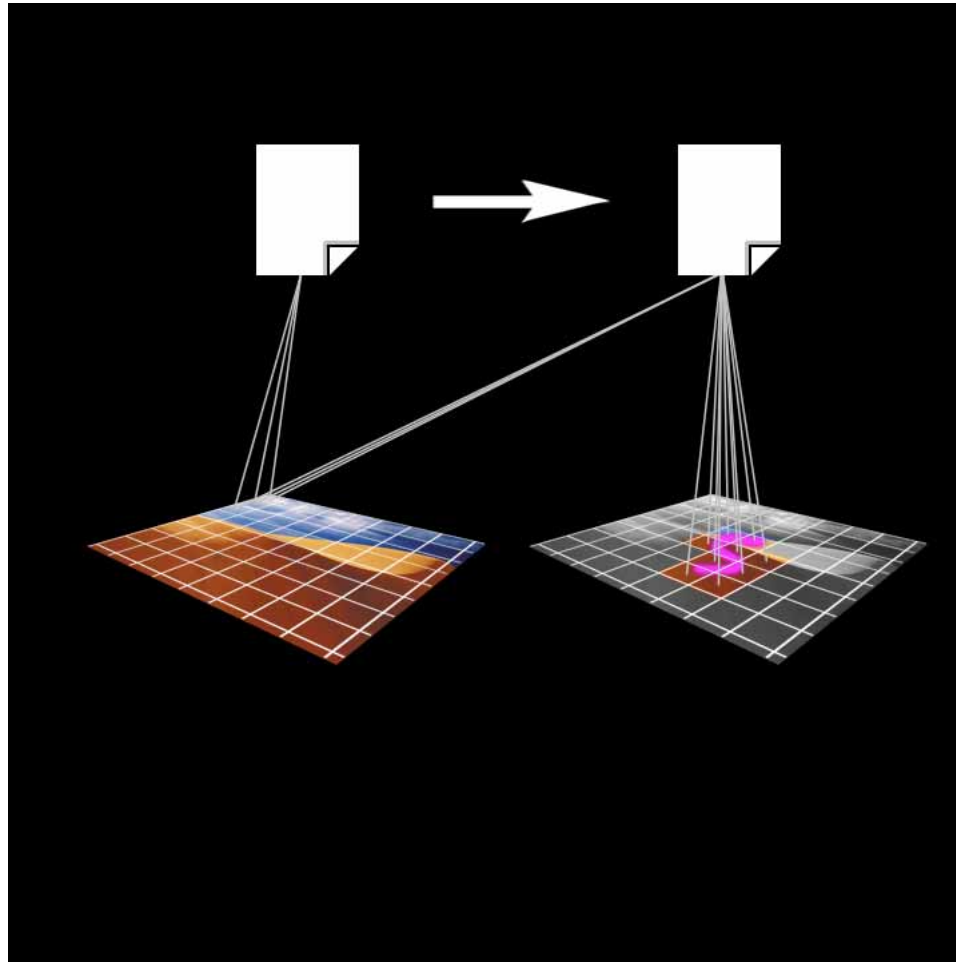
- **Allow the user to state the request in terms of the desired result or to preview the result. This is accomplished by modeling the post-conditions of a functions**
- **Undo, Preview, Non-Destructive Editing and “Direct Manipulation” are all forms of predictive UI that completely model post-conditions**

Example - Text Edit

- To implement Undo we will need a “kill buffer” where we can store text that was erased and where it was erased from
- We will also need to be able to store the range of text that was last inserted



Photoshop History



Demo

Scripting as User Interface

- **Same goals as a visual user interface**
 - assistance sets scripting apart from an API
 - Less emphasis on interactive but still important as scripts often complement the visual interface
- **Document model and functions remain intact**
 - Application model and functions may vary
- **Prediction and Constraints are critical**
 - Defines scripting interface
- **Recording - capturing contributing values. Related to prediction and modeling post conditions.**

Teach & Learn Core Computer Science

- **Algorithms**

-

Links and References

- **Adobe Software Technology Lab:** <http://stlab.adobe.com/>
- **More from the Lab:**
 - http://www.stepanovpapers.com/eop/lecture_all.pdf
- **H.-J. Boehm, R. Atkinson, and M. Plass, "Ropes: an Alternative to Strings", *Software Practice and Experience* 25(12):1315, 1995.**
- **Thanks to Russell Williams for Photoshop code statistics.**



Revolutionizing
how the world engages
with ideas and information

