Mapping Tasks to Interactions for Graph Exploration and Editing

Current Situation:
- Exploration „or“ Editing
- Mouse and Keyboard Interfaces
- Single-User Desktop Environment

Vision:
- Exploration „and“ Editing
- Natural User Interfaces
- Multi-User Multi-Display Environment

**Exploration**
- Select:
  Tasks to mark nodes or edges of interest and to keep track of them.
- Explore:
  Tasks to examine global and local characteristics of the graph, for instance a subgraph of interest.
- Reconfigure:
  Tasks to create a different perspective on a subset, for instance by applying a graph layout algorithm.
- Encode:
  Tasks to alter the visual representation of graph elements or data attributes.
- Abstract & Elaborate:
  Tasks to adjust the level of abstraction of a graph representation.
- Filter:
  Tasks to change the set of displayed nodes or edges based on specific conditions.
- Connect:
  Tasks to establish relationships among nodes, edges or data attributes.

**Editing**
- Create:
  Tasks to create empty documents for new graph data sets.
- Insert:
  Tasks to add new nodes, edges or data attributes to a graph.
- Delete:
  Tasks to remove existing nodes, edges or data attributes from the graph.
- Update:
  Tasks to change characteristics, for instance attribute values of existing nodes or edges in the graph.
- Navigate:
  Tasks to navigate to different subgraphs in order to edit them.
- Select:
  Tasks to mark nodes, edges or data attributes of interest in order to edit them.
- Miscellaneous:
  Additional tasks that do not fit in above categories, such as cutting and copying nodes or edges.

**Interactions**

**Modality**
- Touch Interaction
- Pen Interaction
- Common contact-based interaction modalities for interactive surfaces

**Single/Multi Device and Single/Multi User**
- Type of actuator: touch, hand, pen, type of tangible
- Number of actuators
- Combination of actuators
- Number and role of users

**Gestures Dimensions**
- Continuity/Flow: discrete ↔ continuous
- Duration/Velocity: short ↔ long duration
- Nature of motion: symbolic, physical ↔ metaphorical, abstract
- Linearity of movement: straight ↔ changes in direction

**Object Relations**

A gesture’s meaning can be dependent on the relation to an object. Objects can be classified as part of the gesture when it started on it, crossed it, ended on it, and/or enclosed it.

**Formalization**
Mathematically, a mapping \( m \) from tasks to interactions can be defined as \( m : T \rightarrow I \). To avoid ambiguities, \( m \) must be injective. To set up a usable interaction alphabet, \( m \) has to satisfy a set of certain criteria \( C = [c_1, c_2, \ldots, c_n] \) often referred to as interaction guidelines or design rules such as consistency, predictability or recoverability. Let \( M \) be the set of possible mappings \( F \rightarrow I \). The quality of a mapping \( m \in M \) concerning a specific criteria \( c \in C \) can be expressed with a quality function \( q : M \times C \rightarrow [0, 1] \).

Then, the overall quality of a mapping \( m \) concerning \( C \) can be expressed by the normalized sum \( q = \sum_{i=1}^{n} q_i \). Considering varying criteria priorities in different application contexts, it makes sense to add weight factors to every summand so that the overall quality is expressed by \( q = \sum_{i=1}^{n} a_i q_i \) with \( a_i \in [0, 1] \).

By solving this optimization problem, it becomes possible to set up a mapping with good quality concerning the criteria.

**Touch**
- Changing the node mapping using a touch menu
- Duplicating a subgraph by holding the original and dragging a copy out
- Deleting a node by crossing it out using the pen
- Inserting an edge by drawing it with the pen
- Zooming by moving the device itself

**Pen**
- Using tangibles like a stamp to duplicate nodes

**Tangible**

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