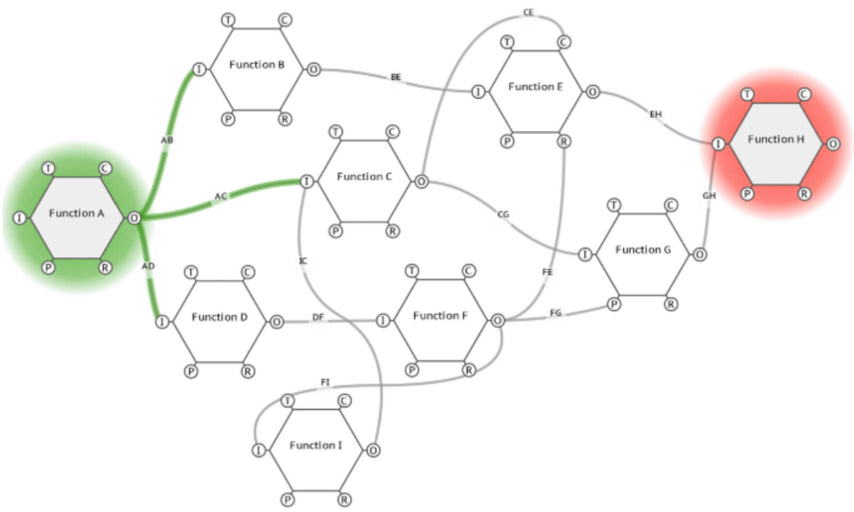
FRAMalyse

Brief Introduction and Background of FRAMalyse

0) What is FRAM?

FRAM is a method for modeling socio-technical systems using functions. These functions are described as hexagons with 6 aspects (Input, Output, Preconsition, Resource, Control, Time) and represent transformation processes of how an input is converted into an output. Functions are connected to other functions via aspects by means of couplings. The output of each function is described by means of a performance variability. These variabilities/adaptations are necessary for the system to function as a whole. Rarely, however, these variabilities also lead to accidents under the phenomenon of "functional resonance". In general, it is important to find out how the variability can spread and aggregate in the system and thus ultimately lead to functional resonance. Positive variability should be amplified and negative variability mitigated.

5min Video: https://www.youtube.com/watch?v=nF9j23L16bs



1) Motivation and goal:

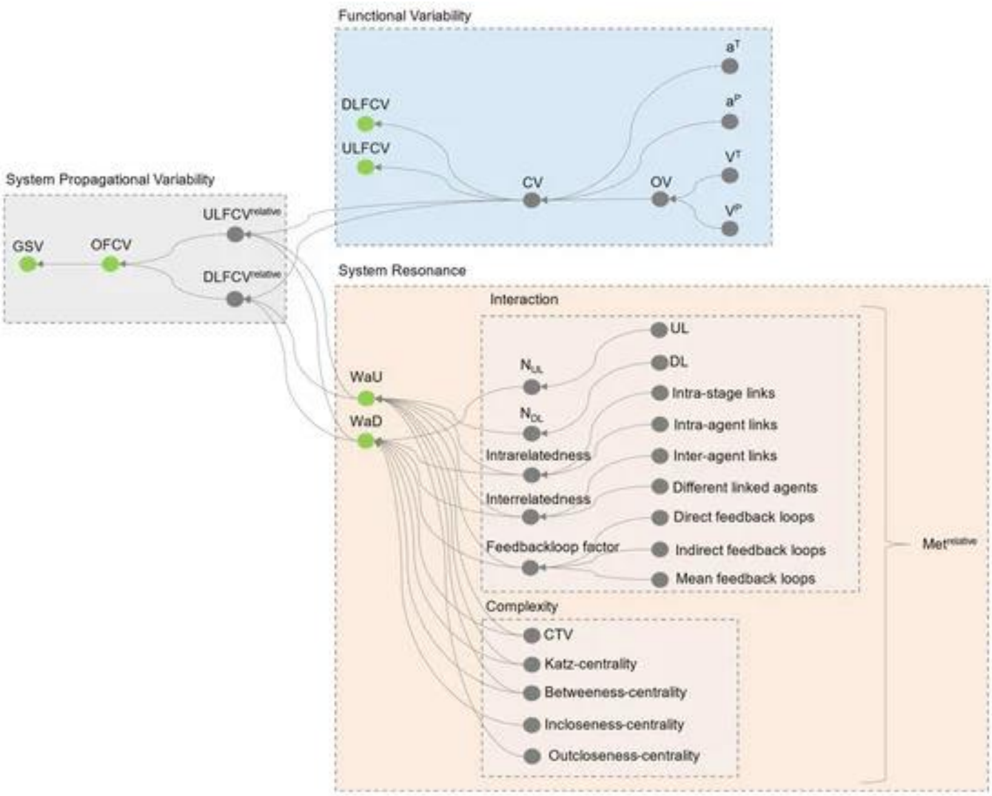
As modern socio-technical systems become increasingly complex, there is a growing need for innovative models and methods for risk and safety management. The Functional Resonance Analysis Method (FRAM) is a newer approach that addresses this complexity. Interest in expanding the capabilities of software tools that support FRAM analysis is increasing. Four well-known examples of FRAM-related tools are: the FRAM Model Visualizer (FMV), which helps create models and graphically represent them, as well as simulating dynamic and emergent system behavior with added metadata; the FRAM Model Interpreter (FMI), which checks the syntactical and logical accuracy of FRAM models and ensures their consistency and completeness; myFRAM, which converts FRAM models into tabular matrices for further quantitative or numerical analysis; and DynaFRAM, which captures both qualitative and quantitative variability, as well as temporal variations. These tools assist in modeling, simulation, visualization, and interpretation of system variabilities. To make working with FRAM models even more user-friendly and to enable more efficient quantitative analysis and evaluation of FRAM models, FRAMalyse has been developed as a new open-source software tool. In contrast to these apps, FRAMalyse stands out due to its high user-friendliness and is especially useful for managing the complexity of large FRAM models. The first version presented here aims to enable practitioners and decision-makers to systematically, efficiently, and effectively explore FRAM models, thereby increasing the acceptance and usability of FRAM in various fields and industries. FRAMalyse is planned as a standalone desktop version with a user manual. FRAMalyse was initially subjected to an Alpha-Test by colleagues from the Chair of Ergonomics at the Technical University of Munich to ensure the functionality of the system. Currently, a Beta-Test is being conducted with international safety and FRAM experts to identify potential new features, optimize the user interface, and enhance the overall user experience.

2) **<u>Main-Features of FRAMalyse:</u>**

- Import of FRAM models from FMV as EXCEL or CSV files
- Parameterization and calculation of indicators/metrics for static system description
    - Classification within the Abstraction-Agency Framework
    - Additionally, implementation of Monte Carlo simulation for systematic variations of model instantiations
- Data visualization
    - Descriptive information on model characteristics
    - Evaluation of global variabilities and identified risk functions and couplings
    - Critical paths / leverage points
    - Comparison of different scenarios of the model
- Export of results as EXCEL or CSV files and image files

3) <u>Metrics/Indicators:</u>

Overview of the structuring of metrics/indicators. The three categories are explained below. The detailed metrics do not need to be further understood but simply acknowledged.



"The **functional variability** represents the variability that a function directly receives and transfers without considering their interaction and effect in the system sufficiently. Therefore, the **system resonance** tries to reflect the interaction and complexity of a function in the system, incorporating non-linearity, emergence, and dynamic of the system. It is a kind of weighting of the impact and affectedness of a function to evaluate the effect of a function variability system-wide. Combining functional variability and system resonance results in **system propagational variability**, which shows the systemwide impact and affectedness of each function's variability up to a global system variability level."

Prozess of the Task

Goal: Beta-Test of the FRAMalyse: Cognitive Walkthrough with Specific Tasks.

1) <u>Basic FRAM Model (used in the test)</u>

- 26 functions with 43 couplings, divided into agents and stages.

2) <u>Tasks for the Cognitive Walkthrough:</u>

The test is intended for the exploration of the software; it is not about speed or the correctness of solving the tasks listed below. Only essential functions are tested in the tasks, not all functions in detail. Afterward, the app can be freely explored.
The FRAM model has already been created in FMV, and the required CSV files have been exported and saved in the directory “2 - Start File\Upload Model Data (Upload Both Files)”.

I. Parameterization and Calculation

1. Run FRAMalyse and Upload Model Data

- **Run FRAMalyse.**
- **Upload the required CSV files** from *Start File\Upload Model Data (Upload Both Files)*:
    - "FMV_new-couplings"
    - "FMV_new-functions"

2. Parameterization

2.1 Modify Function Parameters

- Go to **Menu > Parameterization and Calculation > Agents, stages, and variability manifestation frequencies**
- Click the **question mark** in the top left to view the introduction.
- Modify parameters for **Function A**:
    - Function Type
    - Color of Function Type
    - Agent
    - Stage
    - Variability Frequencies: P_TE, P_OT, P_TL, P_NAA, P_I, P_A, P_PR
    - Order of Agent and Order of Stage
- Click **"Test Data"** to generate random values for testing.

2.2 Modify Variability Manifestation & Propagation Parameters

- Go to **Menu > Parameterization and Calculation > Variability manifestation impact and propagation of variability**
- Click the **question mark** in the top left to view the introduction.
- Modify:
    - Table: Assignment of numerical values to the propagation of variability
    - Table: Assignment of numerical values to the variability manifestation of timing and precision
    - Table: Allocation of numerical values of the weighting factors for WaU and WaD

3. Calculate Metrics

- Go to **Menu > Parameterization and Calculation > Calculating metrics**
- Click the **question mark** to view the introduction.
- **Perform calculation**
- **Review key metrics**:
    - **OFCV and Katz-Centrality** values for **Function K**
- **Download results** as **Excel or CSV**

II. Data Visualization

1. Upload Scenario Data

- Click **the second upload button ("Upload Scenarios")** in the toolbar.
- Upload pre-generated metrics for:
    - **Scenario_1.xlsx**
    - **Scenario_2.xlsx**
- Files are located in *2 - Start File\Upload Scenario*

2. Model Overview & Descriptive Analysis

2.1 Network Analysis

- Go to **Menu > Data Visualization > Basics (Descriptive) > Network of Model**
- Click **the question mark** to view the introduction.

- Answer key questions:
  - Which function has the **highest OFCV**?
  - Which coupling has the **highest CV**?
  - What is the **stage** and **agent** of **Function K**?
    - Click "**Function A"** in the function list
  - Where does this variability **propagate** of **Function K**?
  - Reset network view: Click **"All"** in the function list.

2.2 Model Characteristics & Relationships

- Go to **Menu > Data Visualization > Basics (Descriptive) > Characteristics, frequencies, and interrelationships**
- Click **the question mark** to view the introduction.
- Answer key questions:
  - **Overall number** of functions and couplings
  - How many functions belong to **Agent1**? (See **Treemap**)
  - How many functions belong to **Stage1**?
    - Click **DropDown** above Treemap → Select **"Function-Stage"**

2.3 Variability Analysis (Sankey Diagram & Chord Diagram)

- **Sankey Diagram:**
  - Select **Function K** in the function list:
    - How many functions **receive variability**?
    - How many functions **transfer variability**?
    - Which function transfers the **most variability** and through which aspect?
    - What is the **average CV**?
      - Click the **DropDown** in the **top left corner** of the tab → Select **"Average of coupling variability"**
- **Chord Diagram:**

    - Go to **Menu > Data Visualization > Basics (Descriptive) > Interdependencies – Chord diagram**
    - Click **the question mark** to view the introduction.
    - Click **"Function K"** node to view related information in the table.
    - Click **any chord** of Function K to view details.
    - Use the **filter** to exclude “**Agent4”** nodes.

III. Function & Coupling Evaluation

1. Function Evaluation

- Go to **Menu > Data Visualization > Advanced (Evaluation) > Risk Functions**
- Click **the question mark** to view the introduction.
- Select **risk functions** for both scenarios and start the analysis.
- Go to **Global System Variability and Risk Distribution**
    - Compare **Global System Variability** between both scenarios.
- Go to **Functional Variability System Resonance Matrix**
    - Change **upper boundary** from **30% to 35%**
    - Identify functions with **Functional Variability & System Resonance > 35%**
- Go to **Interaction and Variability**
    - Compare **interaction and variability** between scenarios
    - Find:
        - Function with **highest DLFCV** in **Scenario_1**
        - Function with **highest WaU** in **Scenario_2**

2. Coupling Evaluation (Monte Carlo Simulation)

- Go to **Menu > Parameterization and Calculation > Monte Carlo Simulation**
- Click **the question mark** to view the introduction.
- Set parameters:
    - **Threshold Criticality of CV** = 12

    - **Number of Runs** = 100
    - **Error Probability** = 5%
    - **Longest Paths** = 11
- **Perform Monte Carlo Simulation**:
    - Click **"All Paths"** for both scenarios.
    - Identify:
        - **Two related critical upstream-downstream couplings**.
        - **Critical longest paths of couplings**.
    - **Visualize** critical paths in the **network diagram**.
    - **Download simulation results**.