The Routine Resilience Simulator: An interactive tool for exploring the effects of disruptions on organizational routines[1]

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Abstract

This paper describes the Routine Resilience Simulator, an interactive software application that allows users to explore the effect of disruptions on organizational routines. Users can (a) upload a time-stamped event log that describes an organizational routine; (b) select a portion of the event log to use as a baseline for the simulation; (c) set parameters that describe the magnitude, timing, and duration of the disruption; and (d) simulate and visualize the effects of the disruption on the trajectory of the routine over time.

1 Introduction

Organizational routines are pervasive, but so are disruptions. Disruptions can be small or large, intentional or unintentional, with good or bad outcomes. Since routines are the primary way that organizations deliver products and services to customers, it is important to understand what happens when they are disrupted.

There is a tremendous interest in disruption and resilience in many disciplines including organization theory, supply chain management, safety science, and others. Disruptions can be caused by nearly anything: climate related events, economic events, pandemic, or war. The approach we describe here is focused on a very narrow aspect of resilience that is based on the inherent tendency of routines to persist and "bounce back" over time (Becker, 2004).

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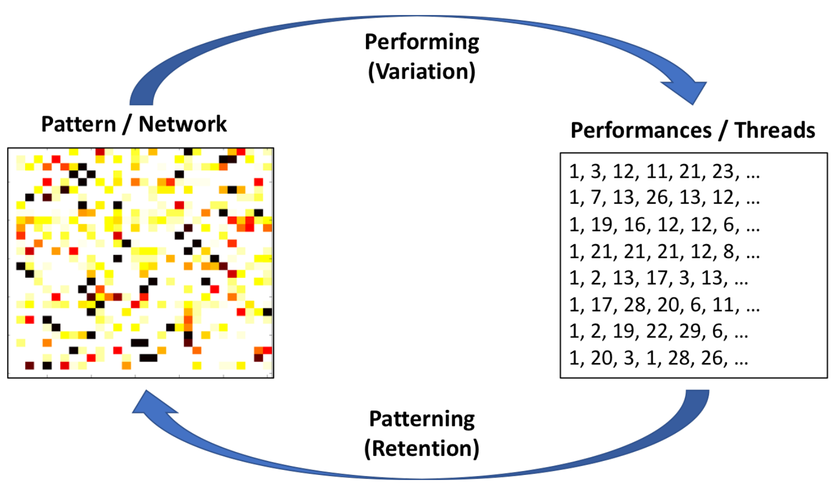
This paper describes the Routine Resilience Simulator (RRS), an interactive software application that allows users to explore the effect of disruptions on organizational routines. The simulation is written in Shiny R, and it is based on prior simulation model by Pentland and colleagues (Pentland, Liu, Feldman, Becker, 2012; Pentland, Liu, Kremser, Haerem, 2020; Pentland, Yoo, Recker and Kim, 2022). The model and the simulation captures the general idea of how variation and repetition influence the trajectory of routines over time, but it does not capture the details of specific situated actions.

2 Background

Organizational routines can be defined as "repetitive, recognizable patterns of interdependent actions carried out by multiple actors" (Feldman and Pentland, 2003, p. 97). These patterns of interdependent action emerge over time and are reproduced, often with minor variations. Most times, the variations are forgotten. Sometimes, the variations are retained and incorporated in the pattern. When this happens, the variation can be reproduced in further performances of the routines. Through this process, the pattern of action can change.

Figure 1 shows the dynamic relationship between the network that represents the process (on the left) and the specific iterations of the process (on the right). The network summarizes the current state of the process; it describes the edges between each of the possible actions. Darker squares represent more frequent edges (deeper ruts in the road). The network is used to generate iterations of the process, which may include variations. Those variations get folded back into the network after each iteration to form new edges.

Figure 1: Basic model of routine dynamics



2.1 Routines are networks of action that change over time

The central idea in the simulation is that routines can be represented as networks of action that change over time. This leads to the idea of using a network time series to represent how routines change over time. Pentland, Vaast and Ryan Wolf (2021) use this idea to *describe* changes in clinical routines over time. Here, we use the same basic idea to *simulate and visualize* changes in routines over time. At regular intervals, we take a snapshot of the pattern/network on the left side of Figure 1.

2.2 Variation and retention of action patterns

When a routine is disrupted, it introduces variations into the pattern of action. The question is: will those variations be retained or will the routine "bounce back"?

3 Example data

In this paper, we use data from a dermatology clinic in the Northeastern United States. The routines in the clinic were disrupted by the COVID pandemic in March 2020. The data we use is from the audit trail of the Electronic Health Record (EHR) system from January through June, 2020.

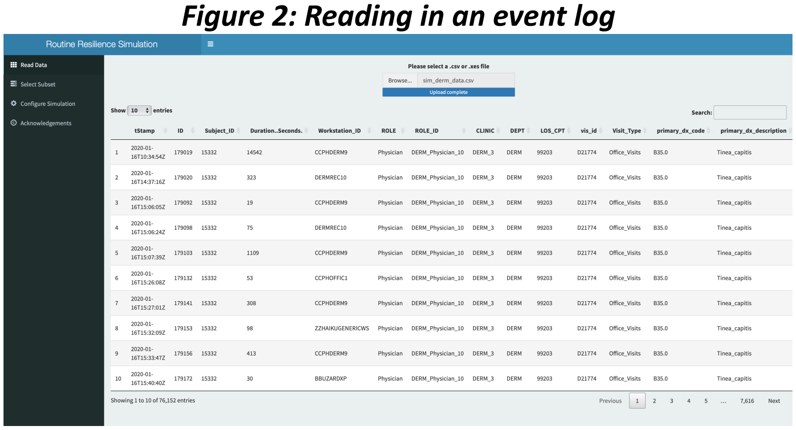
4 Simulation interface

This section describes the functions of the RRS user interface.

4.1 Uploading an event log

You can upload a time-stamped event log that describes an organizational routine. For example, in this paper, we read in six months of data from a dermatology clinic. The first few rows of this data are shown in Figure 2. The simulator can reads in real data from any other time-stamped event log, as long as it is in the right format.

Figure 2: Reading in an event log



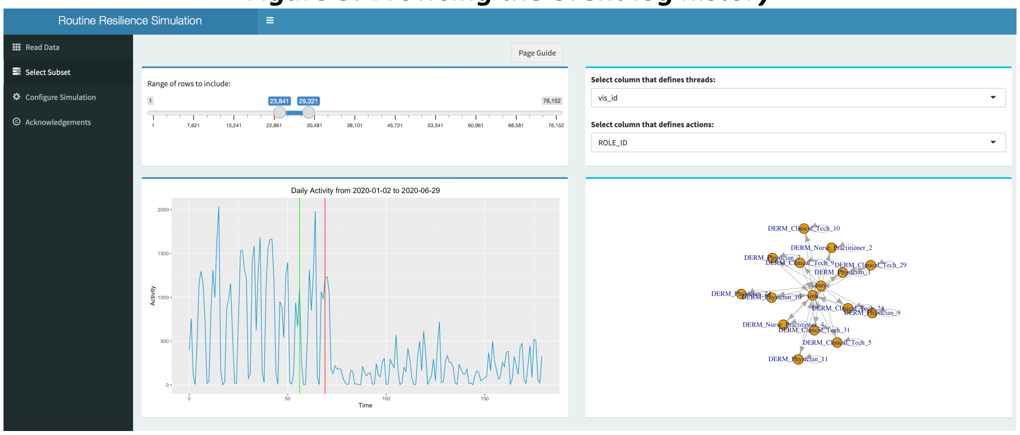
	tStamp	ID	Subject_ID	Duration..Seconds.	Workstation_ID	ROLE	ROLE_ID	CLINIC	DEPT	LOS_CPT	vis_id	Visit_Type	primary_dx_code	primary_dx_description
1	2020-01-16T10:34:54Z	179019	15332	14542	CCPHDERM9	Physician	DERM_Physician_10	DERM_3	DERM	99203	D21774	Office_Visits	B35.0	Tinea_capitis
2	2020-01-16T14:37:16Z	179020	15332	323	DERMREC10	Physician	DERM_Physician_10	DERM_3	DERM	99203	D21774	Office_Visits	B35.0	Tinea_capitis
3	2020-01-16T15:06:05Z	179092	15332	19	CCPHDERM9	Physician	DERM_Physician_10	DERM_3	DERM	99203	D21774	Office_Visits	B35.0	Tinea_capitis
4	2020-01-16T15:06:24Z	179098	15332	75	DERMREC10	Physician	DERM_Physician_10	DERM_3	DERM	99203	D21774	Office_Visits	B35.0	Tinea_capitis
5	2020-01-16T15:07:39Z	179103	15332	1109	CCPHDERM9	Physician	DERM_Physician_10	DERM_3	DERM	99203	D21774	Office_Visits	B35.0	Tinea_capitis
6	2020-01-16T15:26:08Z	179132	15332	53	CCPHOFFIC1	Physician	DERM_Physician_10	DERM_3	DERM	99203	D21774	Office_Visits	B35.0	Tinea_capitis
7	2020-01-16T15:27:01Z	179141	15332	308	CCPHDERM9	Physician	DERM_Physician_10	DERM_3	DERM	99203	D21774	Office_Visits	B35.0	Tinea_capitis
8	2020-01-16T15:32:09Z	179153	15332	98	ZZHAIKUGENERICWS	Physician	DERM_Physician_10	DERM_3	DERM	99203	D21774	Office_Visits	B35.0	Tinea_capitis
9	2020-01-16T15:33:47Z	179156	15332	413	CCPHDERM9	Physician	DERM_Physician_10	DERM_3	DERM	99203	D21774	Office_Visits	B35.0	Tinea_capitis
10	2020-01-16T15:40:40Z	179172	15332	30	BBUZARDXP	Physician	DERM_Physician_10	DERM_3	DERM	99203	D21774	Office_Visits	B35.0	Tinea_capitis

Showing 1 to 10 of 76,152 entries   Previous 1 2 3 4 5 … 7,616 Next

4.2 Browsing the history

You can examine the pattern of action as it changes over time. Figure 1 shows the complexity of the network, day-by-day, from January through June, 2020. We can easily see where the COVID lockdown started in March 2020.

Figure 3: Browsing the event log history



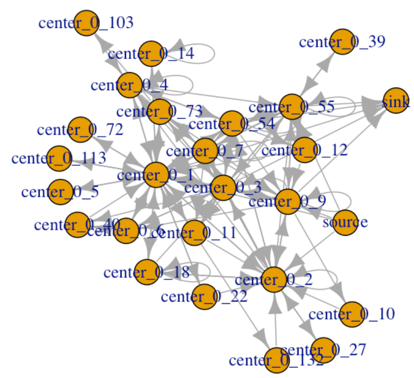
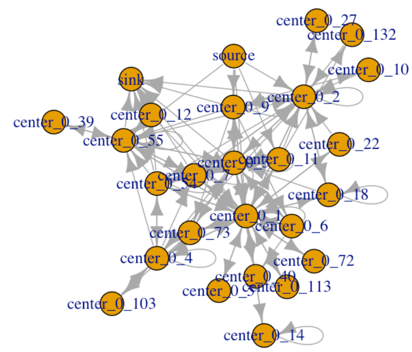
4.3 Selecting a baseline

You can select a portion of the event log to use as a baseline for the simulation. This allows you to pick a section of the event log that is representative of the routine. When you select a portion of the event log (using the sliders), the green and red vertical lines move to show which portion of the event log is selected. In Figure 3, on the right hand side of the screen, the RRS shows the network of action that corresponds to the time period selected. This is the baseline for your simulation.

4.4 Changing the point of view

You can change the point of view used to construct the network used in the simulation. For example, if you trace actions from the point of view of the patient, you get one network. This is labeled the “encounter POV” in Figure 4. If you trace actions from the point of view of the caregivers, you get a different network. This is labeled the “actor POV” in Figure 4. The point of view that you choose will be used as the baseline for the simulation. Each of these networks shows the same set of touchpoints, but the sequential relationship between the touchpoints is defined in a different way, based on the point of view.

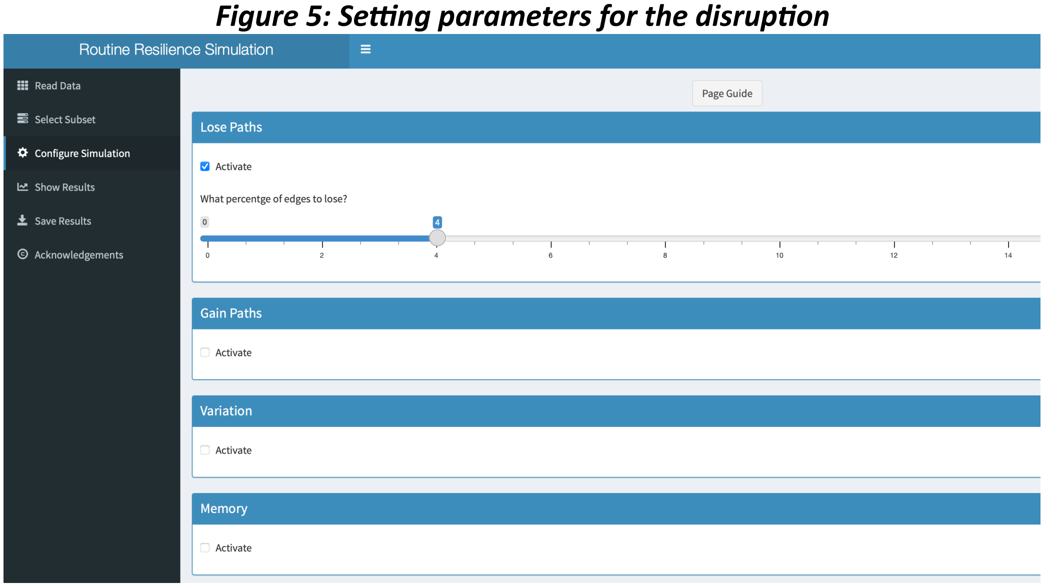
Figure 4: Choosing the point of view for the baseline

Actor POV	Encounter POV
	

4.5 Disrupting the routine

The simulation allows the user to introduce disruptions that change the structure of the routine and its trajectory over time. You can set parameters that describe the magnitude, timing and duration of a disruption. There are four kinds disruptions, each of which has different effects on the routine. These parameters can be activated in any combination.

Figure 5: Setting parameters for the disruption



Losing edges. Edges are the building blocks of paths. Removing edges exponentially decreases the number of possible paths. As a disruption, you can reduce the number of edges in the baseline network by up to 20%. The edges to be deleted are randomly chosen. This reduces the density of the network and reduces the number of possible paths. This disruption occurs once at the beginning of the disruption.

Gaining edges. This is the opposite of losing edges. Adding edges exponentially increases the number of possible paths. As a disruption, you can increase the number of edges in the baseline network by up to 20%. The edges to be added are randomly chosen. This increases the density of the network and increases the number of possible paths. This disruption occurs once at the beginning of the disruption.

When new edges are added, you need to assign an initial weight or strength (0.01 – 0.2). This strength influences the odds of a new edge getting used and reinforced.

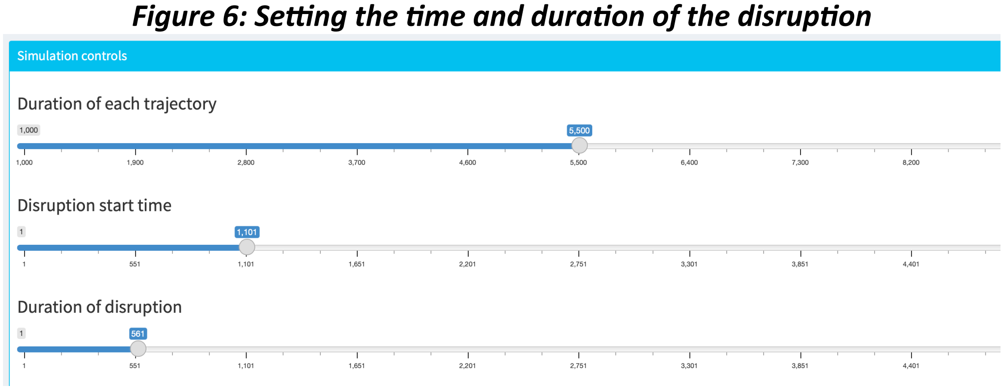
If you choose to do both (lose/gain edges), old edges will be removed and new edges will be added all at same time.

Increased/reduced variation. Variation is the main driver of change in the simulation. Greater variation means greater opportunity for the simulation to generate new paths. The change in variation is expressed as a multiplier on the baseline level of variation (from 0-5x). Values less than 1 will reduce variation and reduce the rate of change. Values greater than 1 will increase variation and increase the rate of change.

Increased/reduced memory. Memory is the other driver of change in the simulation. Greater memory means that variations and new paths are more likely to be retained, but so are old paths. Like variation, the change in memory is expressed as a multiplier on the baseline level of memory (from 0-5x). Values less than 1 will reduce memory, which tends to increase the rate of change. Values greater than 1 will increase memory and reduce the rate of change.

Timing and duration of the simulation and the disruption. The time scale of the simulation is measured in iterations, rather than minutes or hours. You can set the duration of the simulation to last up to 10,000 iterations (this will just take a few seconds to run). Within that overall window, you can locate the starting point and duration of the disruption, also measured in iterations.

Figure 6: Setting the time and duration of the disruption



4.6 Visualizing the effects of disruption

Users can the simulate and visualize the effects of the disruption on the trajectory of the routine over time. Figure 7 shows the result of a particularly severe disruption. Figure 8 shows the network during the disruption depicted in Figure 7.

Figure 7: Visualizing effects of disruption

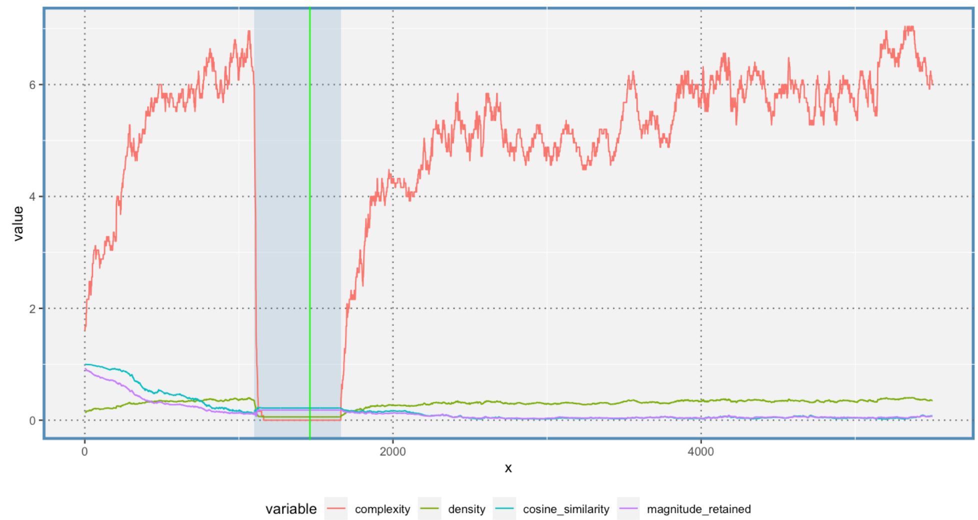
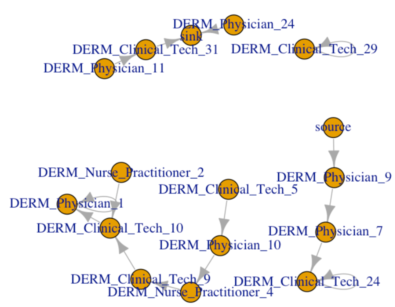
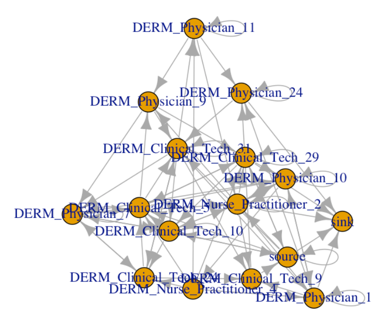


Figure 8: Pattern of action during and after disruption

During disruption	After disruption
	

5 References

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