DyNetVis Documentation

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Contents

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3 Getting Started

The *Dynamic Network Visualization System* (DyNetVis[1]) is an interactive system for visualization of dynamics networks. It has been developed since 2014 [Linhares 2016]. The system helps in the analysis of temporal networks and automates the process of building visualization models. It was developed in Java language, aiming the support for different platforms. The system is developed using a graph library called jgraphx [Alder 2010], that provides functionalities for graph visualization and interaction using Java language.

4 How to open a network

To open a network, first you have to select the desired layout, as illustrated in Fig. 1(a). Currently, there are two options available:

4.1 Temporal and Structural layouts

The Structural layout is the node-link diagram representation, commonly used to visualize graphs. The nodes are represented as circles and the edges as straight lines. The temporal information, in this case, can be represented by an animation. This layout can be selected in the first step of Fig. 1(a).

The temporal layout (also known as Massive Sequence View - MSV) is a timeline representation, where the nodes are disposed vertically and the timestamps are positioned horizontally. More details of this representation can be found in the paper [Linhares et al. 2017]. This layout can be selected in the first step of Fig. 1(a).

The system can be used using a temporal network file or generating a random network, as illustrated in Fig. 1(b).

4.1.1 Temporal Network File format

The DyNetVis system requires a specific file format for temporal and structural layouts, as illustrated in Table 6 and described:

- The file extension can be anyone.
- Each line of the file represents an edge in a specific timestamp, separated by an enter.
- The file must contain 3 columns, divided with spaces. The first, second and third columns represent respectively Node 1 ID, Node 2 ID and Time.
- Each cell also must be represented by a positive integer.
- Time column must be sorted using ascending numerical order.

[1] http://www.dynetvis.com

- Time must start in 0 or 1.
- The order of the Nodes in the file does not impact on the software (e.g., Node 1 ID, Node 2 ID, Time is equal to Node 2 ID, Node 1 ID, Time) as the DyNetVis system only represent undirected graphs.

Table 1: File format example to open temporal networks.

Node 1 ID	**Node 2 ID**	**Time**
10	5	0
3	4	0
2	8	1
3	4	1
2	5	2

4.1.2 Random Network generated

To generate random networks must be selected the following model:

- Barabási-Albert model adaptation: the DyNetVis system uses the proposed model in [Barabási and Albert 1999], adding the possibility of having multiple nodes in each timestamp, as proposed by [Pham et al. 2015].

4.1.3 Time filters

The user can manipulate the Time of the file or the random network generated, by choosing the Minimum, Maximum or changing the Resolution (scale of time), as illustrated in Fig. 1(c).

The Resolution (timeslicing) procedure rearranges the data in the temporal dimension, grouping connections from subsequent timestamps. Eq. 1 represents the change in the temporal resolution for the option *"Static (Uniform)"*. In this equation, t'_{new} is the new timestamp, t_{ori} is the time stamp on the original resolution, t_{s} is the first time stamp and δ is the resolution factor, i.e., the scale in which the time will be modified. For instance, if $\delta = 2$, the new resolution will be double the original and the network will have half of the timestamps when compared to the original.

$$t'_{\mathrm{new}} = \left\lfloor \frac{t_{\mathrm{ori}} - t_{\mathrm{s}}}{\delta} \right\rfloor \delta + t_{\mathrm{s}} \tag{1}$$

Two other resolution methods are available in this version of the system: *"Balanced Visual Complexity"* [Wang et al. 2019] and *"Adaptive Resolution"* [Ponciano et al. 2020]. When this last method is chosen, the user must inform two parameters: the window size (in terms of number of timestamps) and the fading factor α, where $0 \ll \alpha \leq 1$. Finally, the OK button opens the network, as illustrated in Fig. 1(d).

4.2 Matrix layout

The matrix layout, also known as the adjacency matrix, is a square matrix and symmetric. The cells represent edges, and each column and row represents the nodes in the network [Wu et al. 2008]. The temporal information, in this case, can be represented by an animation. This layout can be selected in the first step of Fig. 1(a).

4.2.1 File format

The same idea from the temporal and structural, as depicted in Section 4.1.1.

4.2.2 Time filters

The same idea from the temporal and structural, as depicted in Section 4.1.3.

In the end, the OK button opens the network, as illustrated in Fig. 1(d).

4.3 Community layout

The Community layout is used for Communities Detection Algorithms to compare two different algorithms. Each cell is represented by a node, and each line represents a different community [Linhares et al. 2020]. This layout can be selected in the first step of Fig. 1(a).

4.3.1 File format

The same idea from the temporal and structural, as depicted in Section 4.1.1. The network selected must have other metadata file for nodes associated with this network. More information about the metadata file for nodes in Section 5.1.3.

4.3.2 Time filters

The same idea from the temporal and structural, as depicted in Section 4.1.3.

In the end, the OK button opens the network, as illustrated in Fig. 1(d). Then, the system presents the screen to selection file for nodes metadata. After selecting this file, press the Open button.

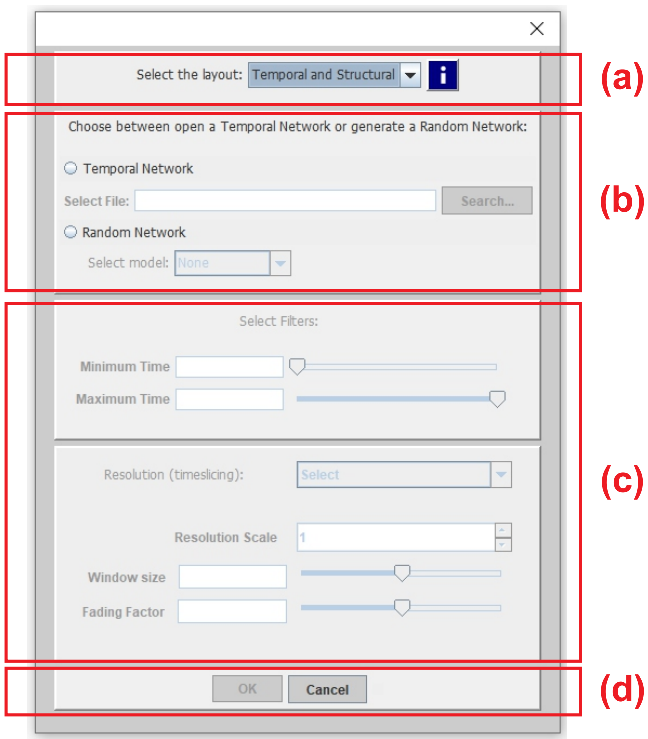

Figure 1: Open file window.

5 Interacting with the layout

There are some possible interactions in the layouts implemented by DyNetVis, as choosing colors, select nodes, zooming and panning, and animation settings, described as follows.

5.1 Choosing colors for nodes and edges in temporal and structural layouts

5.1.1 Colors scales

The system provides pre-defined linear scales of colors between two colors, as listed in Table 2, or can be chosen a linear color scale by manually selecting two colors. The option "Color" is the color scale for nodes in temporal layout, which represents the degree of the node in each timestamp. The option "Color" for the structural layout represents the accumulated degree of the node in all timestamps.

Table 2: Linear colors scale options in DyNetVis.

Gray Scale
Green to Red
Blue To Red
Rainbow Scale
Blue to Cyan
Blue to Yellow
Green To White Scale
Heated Object Scale
Linear Gray Scale
Locs Scale
Orange To Blue Sky
Blue Sky To Orange

5.1.2 Random colors

The system provides the option of selecting random colors for nodes and edges in the structural and temporal layouts. In temporal layouts, it can be chosen "Random Color", that represents a single color for each node in each timestamp, or "Random Line" that represent a single color for each note in all timestamps that has connections.

5.1.3 Metadata

There are implemented in DyNetVis system three types of metadata: for Nodes ("Metadata File"), Edges without Time ("Metadata Without Time") and Edges

With Time ("Metadata File").

Metadata of nodes

The DyNetVis system requires a specific file format for metadata of Nodes, as illustrated in Table 3 and described:

- The file extension can be anyone.
- Each line of the file represents a node, separated by an enter.
- The file must contain 2 columns, divided with spaces. The first and second columns represent respectively Node identification (node ID) and a single Metadata for that node.
- The node ID cell must be a positive integer, and the Metadata cell must be a string.
- Metadata column must be grouped by type.
- Nodes not associated by any Metadata will be colored as black.
- Metadata only supports 10 different types (each one associated with a different color). More metadata types can be inserted, but they will be associated with black color.
- The order of the types of metadata inserted in the file directly impacts the color chosen. They will be associated with the number order in Fig. 2.

Table 3: File format example for metadata of nodes.

Node ID	**Metadata**
10	Teacher
5	Teacher
2	Student
1	Student
2	Student
4	Student
8	Manager
3	Manager

Figure 2: Color scale for metadata.

Metadata of edges

The DyNetVis system requires a specific file format for metadata of Edges, as illustrated in Table 4 and described:

- The file extension can be anyone.
- Each line of the file represents an edge, separated by an enter.
- The file must contain 3 columns, divided with spaces. The first, second and third columns represent respectively Node 1 identification (node 1 ID), Node 2 identification (node 2 ID) and a single Metadata for that edge.
- The node ID cells must be positive integers, and the Metadata cell must be a string.
- Metadata column must be grouped by type.
- Nodes not associated by any Metadata will be colored as black.
- Metadata only supports 20 different types (each one associated with a different color). More metadata types can be inserted, but they will be associated with a random color.
- The order of the types of metadata inserted in the file directly impacts the color chosen. They will be associated as the order in Fig. 2.

Table 4: File format example for metadata of edges.

Node 1 ID	**Node 2 ID**	**Metadata**
10	5	Science
3	4	Science
2	8	Literature
2	5	Sport

Metadata of edges/nodes with Time

The DyNetVis system requires a specific file format for metadata of Edges/Nodes with Time, as illustrated in Table 5 and described:

- The file extension can be anyone.
- Each line of the file represents an edge with time, separated by an enter.
- The file must contain 4 columns, divided with spaces. The first, second, third and fourth columns represent respectively Node 1 identification (node 1 ID), Node 2 identification (node 2 ID), Time of connection between node 1 and node 2, and a single Metadata for that edge.

- The node ID and Time cells must be positive integers, and the Metadata cell must be a string.
- Metadata column must be grouped by type.
- Nodes not associated by any Metadata will be colored as black.
- Metadata only supports 20 different types (each one associated with a different color). More metadata types can be inserted, but they will be associated with a random color.
- The order of the types of metadata inserted in the file directly impacts the color chosen. They will be associated as the order in Fig. 2.

Table 5: File format example for metadata of edges/nodes with time.

Node1ID	**Node2ID**	**Time**	**Metadata**
10	5	0	Science
3	4	0	Science
2	8	1	Literature
3	4	1	Literature
2	5	2	Sport

5.2 Choosing colors for edges in matrix layout

The options to change node colors in the Matrix layout are:

- None: Default option, where all edges are associated with black color.
- Random: Each edge in the layout is associated with a random color.
- Communities: Each edge will be associated with a color correspondent to a selected community algorithm. An edge to be colored as a single color, both source and destiny nodes of this edge must be associated with the same community. Otherwise, the node will have the border color of the source node, and the fill color of the target node. The community color will follow the color scale in Fig. 2.
- Intra Communities: Each edge will be associated with a color correspondent to a selected community algorithm. An edge to be colored as a single color, both source and destiny nodes of this edge must be associated with the same community. Otherwise, the remaining edges will be associated with black color. The community color will follow the color scale in Fig. 2.

- Only Communities: Each edge will be associated with a color correspondent to a selected community algorithm. An edge to be colored as a single color, both source and destiny nodes of this edge must be associated with the same community. Otherwise, the remaining edges will be hidden in the layout. The community color will follow the color scale in Fig. 2.

- Metadata File: Each edge will be associated with a color correspondent to the metadata file. The file format is the same as "Metadata of nodes", with Node ID and Metadata information. The remaining edges will be associated with a light gray color. The metadata color will follow the color scale in Fig. 2.

5.3 Changing nodes/edge size and form

:

In Structural layout, the options for the Node Size are:

- Original: default size for nodes, which can be considered small.

- Degree: the size of nodes are related to the accumulated degree of the node.

- Big: the size of all nodes are changed to "Big".

In Structural layout, the options for the Edge Stroke are:

- Original: default size for edges, related to the width, which can be considered small.

- Stroke Edges: the width of the edge variate according to the number of connections that the two nodes of that edge have.

In Structural layout, there is an option to import/export the nodes position, where they are saved/open in an external file. The file format is:

- The file extension can be anyone.

- Each line of the file represents a node, separated by an enter.

- The file must contain 3 columns, divided with spaces. The first, second and third columns represent respectively Node ID, X and Y.

- The node cell must be represented by a positive integer.

- The X and Y position must be represented by a double number and has to be a positive value to be positioned in the screen.

In Temporal layout, the options for the Node Size are:

- Small: default size for nodes, which is small.

Table 6: File format example to import the nodes position on structural layout.

Node ID	X	Y
10	2238.0	414.0
3	2262.0	0
45	8	1
1	2262.0	339.0
22	5	564.0

- Big: the size of all nodes are changed to “Big”.
- Custom: A feature to allow the input value for the size of the node and edge, as seen in Fig. 3. Default values are: Node Size 10, Edge Size 1. This functionality is ideal to increase the size of nodes and edges in cases where the “Space Temporal” is higher than 1.

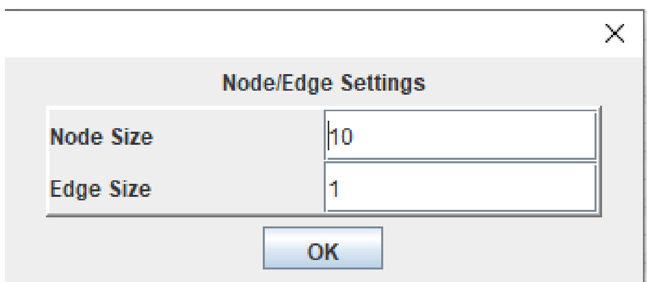

Figure 3: Node/Edge settings window.

In Temporal layout, the options for the Node Form are:

- Circular: the form of all nodes in the layout is changed to circular (default).
- Square: the form of all nodes in the layout is changed to a square.

5.4 Selecting nodes in temporal/structural layouts

The system provides ways of selecting elements (nodes/edges/times): dragging a box around a series of elements to select everything within the box, or clicking on the element itself. To select multiple elements that are not in line, you can press Ctrl and click on each element to select all of them. More details on how to select nodes, timestamps, and highlight specific edges can be found in [Linhares et al. 2019a]. The temporal and structural layouts are coordinated, i.e., if a node is selected in the structural layout the same node is selected in the temporal layout. More details about the coordination can be found in [Linhares et al. 2017].

The temporal layout also provides a "search", in Find Node, where the node can be searched and centered by the Node ID.

5.5 Zooming and panning

The system also provides scroll bars for all the layouts, the option of zoom in and out (also in the mouse scroll wheel). To enhance the overview of the layout, the ideal button is "Zoom Fit" where the layout is fitted on the screen. "Zoom Default" presents the initial configuration in the system.

5.6 Animation settings in structural/matrix layouts

Structural and Matrix layouts provide animation settings, which illustrate the animation process for both layouts. The animation runs based on the timestamp, demonstrating the nodes/edges of each timestamp. The system also provides an "Aging" label, where the user can choose the transition factor for the animation at each timestamp. The user can also accelerate (Speed), run and stop the animation process.

5.7 Particular layout settings

Each layout has its particular settings, as follows.

5.7.1 Structural settings

Some options are: Show/Hide nodes, edges, edges weight, node ID. The system also provides a depth selection, with an input of the level of the depth selection.

5.7.2 Temporal settings

The options are: Show/Hide nodes, and Show node lines. The Show All Inline Nodes option is to plot nodes only in the timestamps where there are a active edge between the selected nodes. The system can also apply Temporal Activity Map (TAM) [Linhares et al. 2017], with the background colored as blank (TAM White), with the background colored as the first color of the scale (TAM Color) and with the TAM Opacity, where can be applied to any color scale, which highlights nodes higher degree at the timestamp (preferably used with hidden edges). The system also provides a depth selection, with an input of the level of the depth selection. The software provides a feature to increase the vertical and horizontal space in the temporal layout, configurable as shown in Fig. 4.

5.7.3 Matrix settings

The option is to "Show Triangular Matrix", which highlights edges above the main diagonal, hidden the others.

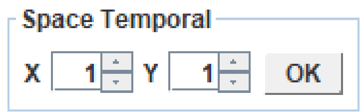

Figure 4: Space in the Temporal layout window.

5.8 Export Images

The system provides an Export Image option for all the layouts available (Fig. 5). The options for the format are provided by the jgraphx library: SVG, PNG, JPG and GIF. The “Select Quality” input is related to the resolution of the image. The values vary from 0.1 to infinite, however, the recommended value is 1. Values too high can cause the “Java heap space” error. For large networks (thousand of nodes and edges), in layouts such as Temporal, is recommended values smaller than 1. “Back. Color” is related to the background color of the exported image.

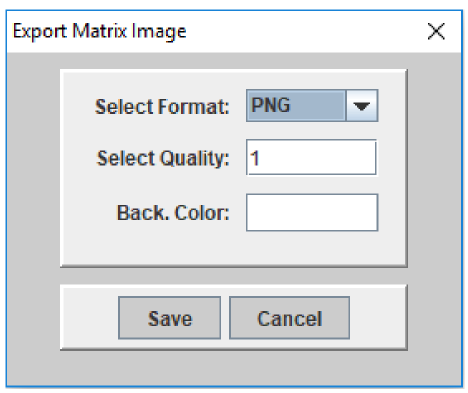

Figure 5: Export Image window.

6 Features

DyNetVis system implements several important and state-of-art features related to temporal networks, as described as follows.

6.1 Node ordering/positioning methods

6.1.1 Temporal layout

Node ordering for Temporal layout:

- Appearance: Nodes are sorted on ascendant order they appear on the network.
- Random: Nodes are sorted randomly.
- Degree: Nodes are sorted in ascendant order by their accumulated degree.
- Recurrent Neighbors: Try to approximate the nodes based on its connections and degree in the central part of the layout, as described by in [Linhares et al. 2017].
- CNO: Community Node Ordering (CNO) is a visual scalable technique that combines network community detection algorithms with node reordering strategies. It also provides some community edge filters in the layout, a described in [Linhares et al. 2019a].
- File: Nodes are ordering according to an order described in a file. More details as follows.
- Selected Nodes: Nodes are ordering according to the current node selection. The selected nodes are positioned in the top of the layout.

CNO details

CNO method requires three main parameters: community detection algorithm, inter-community reordering, and intra-community reordering, as illustrated in Fig. 6.

For the community detection algorithm, DyNetVis provides two algorithms: Louvain [Blondel et al. 2008] and Infomap [Rosvall and Bergstrom 2008]. For the inter-intra reordering, there are two options implemented: Degree and Recurrent Neighbors. The system also provides an option to add blanked spaces between the communities in the temporal layout. As CNO is a hierarchical approach, the level limit can be selected (typing in the input CNO Limit Levels) or selecting the Maximum, which means the detection algorithm will try to split the communities as long as possible. Values too high can make this process take a long time for large networks. As this can be a process that can take too much time, the system provides the options to Save File and select a file address to save this file, or also the option to Open File, using this saved file.

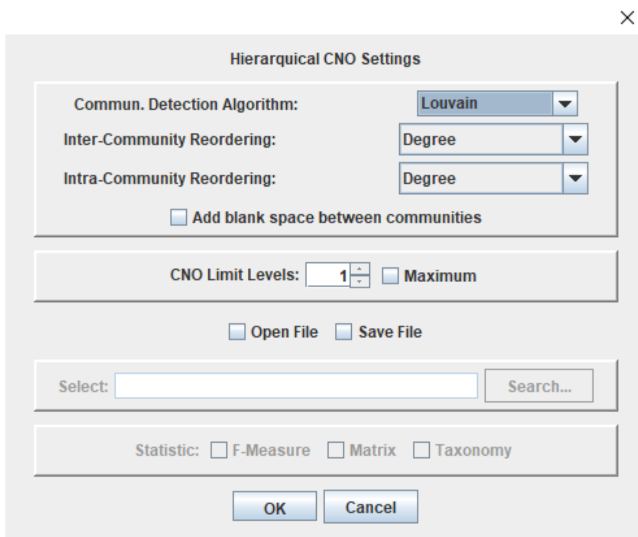

Figure 6: CNO settings window.

File to node ordering details

The DyNetVis system requires a specific file format for open a new node ordering, as illustrated in Table 7 and described:

- The file extension can be anyone.
- Each line of the file represents a node, separated by an enter.
- The file must contain 1 column. The first column represents respectively Node identification (node ID).
- The node ID cells must be positive integers.

6.1.2 Structural layout

The system provides several ways of positioning the nodes in the structural layout. With the exception of the random placement of nodes in the layout (RandomLayout), all the other options are implemented in the jgraphx library [Alder 2010], as follows:

- mxFastOrganicLayout: Nodes are positioned in the layout based on strength algorithms (force-directed layout). The force can be increase to separate more the nodes in the layout, as seen in Fig. 7. Default value is: 40.
- mxCircleLayout: Nodes are positioned in the layout using a circular representation.

Table 7: File format example for file to open a new node ordering in temporal layout.

Node ID
10
5
2
1
2
4
8
3

- mxCompactTreeLayout: Nodes are positioned in the layout using a tree structure representation.
- mxHierarchicalLayout: Nodes are positioned in the layout using a hierarchical structure representation.

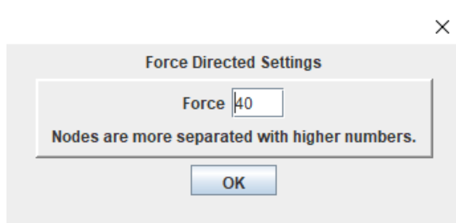

Figure 7: Force-directed settings window.

6.1.3 Matrix layout

Node ordering for matrix layout:

- Appearance: Nodes are sorted on ascendant order they appear on the network.
- Random: Nodes are sorted randomly.
- Degree: Nodes are sorted in ascendant order by their accumulated degree.
- Recurrent Neighbors: Try to approximate the nodes based on its connections and degree in the central part of the layout, as described by [Linhares et al. 2017].
- Louvain: Nodes are sorted in the matrix using the result of the community detection algorithm Louvain [Blondel et al. 2008].

- Infomap: Nodes are sorted in the matrix using the result of the community detection algorithm Infomap [Rosvall and Bergstrom 2008].

6.2 Edge sampling methods for the temporal layout

- Random: Edges are sampled at random.
- AR: Edges are sampling using the accept-reject concept for temporal layout, as described in [Zhao et al. 2018].
- EOD: Edge Overlapping Degree (EOD) uses the kernel density estimation to create an edge overlapping degree and characterize temporal features of node pairs, being able to choose which edges are hindering the analysis [Zhao et al. 2018].
- SEVis: A streaming edge sampling method based on community detection and the most frequent nodes of the network [Ponciano 2020]. For this method, the user must indicate which community detection algorithm will be used, the number k of the top-k most frequent nodes that will be monitored by Space-Saving [Metwally et al. 2005], and the threshold used to decide whether a new community detection is necessary (T_r).
- Reservoir: Each new edge (the i^{th} edge, $i > k$, where k is the reservoir size) has a uniform probability (k/i) of being accepted and replace a randomly selected reservoir edge [Vitter 1985].
- Partial-PIES: *Partially Induced Edge Sampling (PIES)* [Ahmed et al. 2013] is a method that combines streaming edge sampling with partial network induction in a single pass execution. Partial-PIES refers to the application of PIES on each window of timestamps.

6.3 Network Properties

Network properties have general properties of the network, as some statistical measures for the temporal layout, as illustrated in Fig 8 and described as follows.

6.3.1 General Properties

The system provides network information, such as the name, resolution, number of nodes, edges, and timestamps.

6.3.2 Temporal Properties

The system also provides some statistical measures specifically for the temporal layout, such as the number of Overlapping Edges, the average and the standard deviation of the edge size, and intersections, all described in detail in [Linhares et al. 2019a].

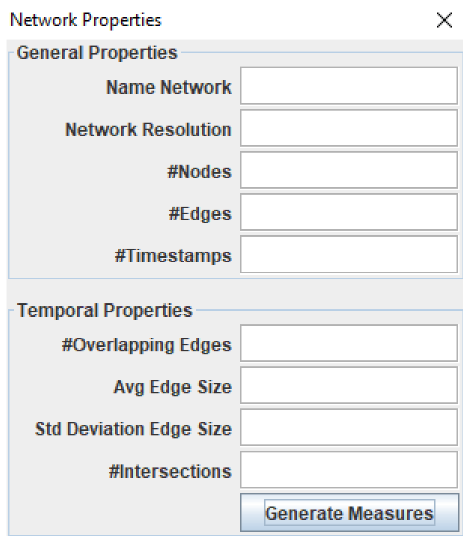

Figure 8: Network properties window.

6.4 Dynamic Processes on temporal layout

The system provides some dynamic processes, such as a random walker and epidemiology [Linhares et al. 2019b], that works exclusively on the temporal layout, as described as follows.

6.4.1 Random Walker process

The random walker process requires the user to select a specific node in a specific timestamp. Moreover, the probability of the random walker move to another node is defined by the input "probability", that can be double values between 0 and 1, as illustrated in Fig. 9.

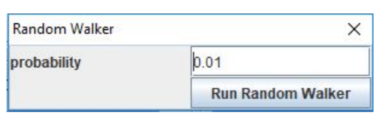

Figure 9: Random Walker window.

6.4.2 Epidemiology Process

The epidemiology process requires the user to select a specific node in a specific timestamp. Moreover, the probability of the epidemiology to spread in the network is defined by the input "probability", that can be double values between 0 and 1, as illustrated in Fig. 10. The user can also select the defined infection model, with the following options: SIR, SIS, SI, and SIRS. The input "Seed to Random" defines the seed value to the random number and this value must an integer. The "Recovery Time" is related to the time of a node costs to recover from an infection (only available in some models), with this field only accepting integer values. The "Loss of immunity" input is a probability value of the infected node to loss the immunity, with double values between 0 and 1.

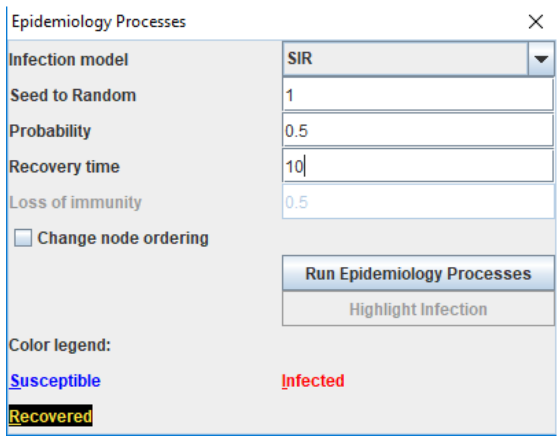

Figure 10: Epidemiology window.

The system also provides a node ordering based on the epidemiology model, where the patient zero of the infection will be located in the center of the temporal layout, and the following infected nodes will be located around the first node. After running the epidemiology process, the user can highlight the infection, altering with different visualizations of the same infection. The states susceptible, recovered and infected are represented by the blue, yellow and red color, respectively.

6.5 Community layout

The system implements the following methods to compare community detection algorithms: Louvain and Infomap. First, to generate the layout to compare the community detection algorithms you must click on the Equivalence button. The default threshold to generate the Equivalence is 70%. More information about this threshold is described in [Linhares et al. 2020]. The square nodes are the nodes for the Louvain algorithm and the circle nodes are the Infomap ones. Inside each node there is a label that represents on the top the metadata class of the node and in the bottom the id of the node.

After pressing the Equivalence button, three different layouts will be generated. The top one is the equivalent nodes between the two detection algorithms. The middle one represents the non-equivalent communities of the Louvain method and the bottom one represents the non-equivalent communities of the Infomap method.

7 Thresholds fixed for specific methods

Some methods used in the DyNetVis system have fixed thresholds, for all the occurrences of these methods in the system, as described below.

7.1 Infomap

For the Infomap method [Rosvall and Bergstrom 2008], the fixed thresholds are:

- Seed: A seed (integer) to the random number generator. (Adopted value: 1)
- Number of attempts: The number of outer-most loops to run before picking the best solution. (Adopted value: 10)

7.2 Louvain

For the Louvain method [Blondel et al. 2008], the fixed thresholds are:

- Seed: A seed (integer) to the random number generator. (Adopted value: 0)
- Resolution parameter: The resolution parameter determines the granularity level at which communities are detected. (Adopted value: 1)
- Number of random starts. (Adopted value: 10)
- Number of iterations per random start. (Adopted value: 10)

7.3 AR and EOD

For the AR and EOD methods [Zhao et al. 2018], the fixed thresholds are:

- Bandwidth σ: Sigma of Gaussian kernel, which controls the smoothing degree of PDFs. (Adopted value: 5)
- Sampling factor F: As F increases, the sample size decreases (i.e., fewer accepted edges). (Adopted value: 2)

7.4 Reservoir Edge Sampling

For the reservoir sampling [Vitter 1985], $k = |E|/3$, where $|E|$ is the number of edges in the network. For details, see Section 6.2.

8 Software Complete License

Preamble

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