Software project: analysis of gene regulatory networks
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Ling Sun Exercises from: 06/Mar/2017 Hand in date: 13/03/2017

Exercises: creating ASTGs from models and In ASTGs: row properties

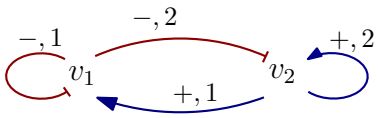
1 Model conditions

Exercise 1. For the model in Figure 1, does the model satisfy:

1. the visibility condition?
2. the observability condition?
3. the Snoussi-condition?

If not, write down the reason. (You may need to check the definition of the model conditions.)

I



K

ω	$K(v_1,\omega)$	ω	$K(v_2,\omega)$
ϕ	0	ϕ	0
$\{v_2\}$	2	$\{v_2\}$	2
$\{v_1\}$	1	$\{v_1\}$	2
$\{v_1,v_2\}$	1	$\{v_1,v_2\}$	2

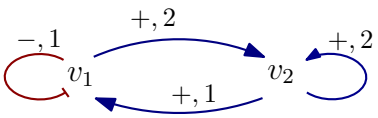
Figure 1: A model $M = (I, K)$. $max(v_1, v_2) = \{2, 2\}$.

Exercise 2. For the model in Figure 2, does the model satisfy:

1. the visibility condition?
2. the observability condition?
3. the Snoussi-condition?

If not, write down the reason. (You may need to check the definition of the model conditions.)

I



K

ω	$K(v_1,\omega)$	ω	$K(v_2,\omega)$
ϕ	0	ϕ	0
$\{v_2\}$	1	$\{v_2\}$	0
$\{v_1\}$	1	$\{v_1\}$	0
$\{v_1,v_2\}$	2	$\{v_1,v_2\}$	2

Figure 2: A model $M = (I, K)$. $max(v_1, v_2) = \{2, 2\}$.

2 ASTG: row properties

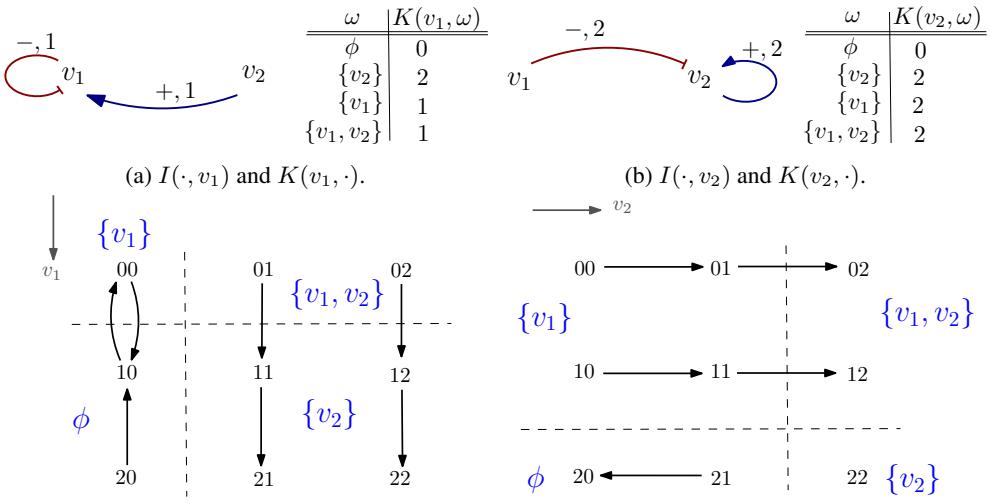
Example 1. *Exercise 3 will be shown as an example, to give an impression, for each component of a model, the relations among:*

- *the resources of a component under all states on the state space,*
- *the logical parameters of this component,*
- *the state transitions in direction of this component.*

Please try to go through and understand this example. Then practise it on Exercise 4.
Exercise 3. Take the model from Fig. 1 (in Exercise 1). Please write down *the state space* (*i.e.*, all possible states), the *resources* of component v_1 on the state space and the *state transitions* in direction of v_1. Afterwards, do the same for component v_2.
Answer. *For every component $v \in V$, let*

- *X be the state space,*
- *$I(\cdot, v)$ be the incoming interactions of v,*
- *$K(v, \cdot)$ be the logical parameters of v,*
- *$\mathrm{Res}_v(x)$ be the resources of v under state x, and*
- *$\delta(v, x)$ be the state transition of x in direction of v,*

Fig. 3c shows an impression on how the resources of v_1 on the state space can look like, as well as their transitions on direction of v_1. Fig. 3d shows those for v_2. Fig. 3a is the assistant information to achieve the Fig. 3c, so is Fig. 3b for Fig. 3d.



(a) $I(\cdot, v_1)$ and $K(v_1, \cdot)$.

(b) $I(\cdot, v_2)$ and $K(v_2, \cdot)$.

(c) $\mathrm{Res}_{v_1}(x)$, and $\delta(v_1, x)$, for all $x \in X$.

(d) $\mathrm{Res}_{v_2}(x)$, and $\delta(v_2, x)$, for all $x \in X$.

Figure 3: (a) Incoming interactions of v_1 and the logical parameters $K(v_1, \cdot)$. (b) Incoming interactions of v_2 and the logical parameters $K(v_2, \cdot)$. (c) Resources of v_1 in each state of the state space, the state transitions in direction of v_1. Eg. $\mathrm{Res}_{v_1}(00) = \{v_1\}$, as written beside 00 in (c). (d) Resources of v_2 in each state of the state space, the state transitions in direction of v_2.

Exercise 4. Take the model from Fig. 2. Please write down *the state space* (*i.e.*, all possible states), the *resources* of component v_1 on the state space and the *state transitions* in direction of v_1. Afterwards, do the same for component v_2.
Exercise 5. Suppose you have already the result from Exercise 4, otherwise (if in case you do not have it yet), then take the results (Fig. 3c and Fig. 3d) from Exercise 3.

Please find out all the row types which are contained in the state transitions in direction of both components, and write it down for each row type at least one example.
Exercise 6. Let $\tau^u = (x^0, x^1, x^2)$ be a u-row of length 3 (including three states), with $x_u^0 = 0$, $x_u^1 = 1$ and $x_u^2 = 2$.

Please enumerate all possible u-rows of length 3. (Hint, check the definitions of all 3 types of u-rows in slide-15, 16, 17 from our lecture. Fig. 4 shows one example.)

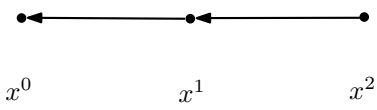


Figure 4: For example, this is one possible u-row as an *open* type.

3 Programming preparation: from models to the ASTG

(a) Which kind of data structures do we need, for the following objects?

(1) IG $I = (V, E, \vartheta, \varepsilon, max)$;

(2) Logical parameter function $K : K(v, \omega)$, for all $v \in V$ and for all $\omega \subseteq \mathrm{Pre}(v)$.

(3) ASTG $T_M = (X, S_M)$, X: state space, S_M: transitions among all states in X.

(b) Based on the date structures above, how can you construct the ASTG from a given model?

Please think about this programming task (we will do it from our next meeting). Note that:

1. be prepared on the basic knowledge of either Matlab or Python that you are going to use in this software project.
2. if you have known already how to implement the task, please write down your strategies and/or pseudocode (if you have it). If you only have partially the strategies, also please write down them.
3. keep in record about the part you are not sure about, because we will discuss it during our next meeting.
4. feel free to go forward if you have the energy to code.