Supplementary material for the article "Alpha-cut based fuzzy cognitive maps with applications in decision-making"

DATA AND RESULTS RELATED TO:

RADIOTHERAPY TREATMENT PLANNING

Table S.4 Strengths of causal relationships in radiotherapy planning model

Causal connection	Sign	Strength of causal relationship		
		Crisp	T1 fuzzy	IT2 fuzzy
$C_1 \rightarrow C_7$	+	0.5	(0.4,0.5,0.6)	((0.4,0.5,0.6;1),(0.45,0.5,0.55;0.8))
$C_2 \rightarrow C_1$	+	0.3	(0.05,0.3,0.55)	((0.05,0.3,0.55;1),(0.1,0.3,0.5;0.8))
$C_2 \rightarrow C_7$	+	0.6	(0.5,0.6,0.7)	((0.5,0.6,0.7;1),(0.55,0.6,0.65;0.8))
$C_3 \rightarrow C_2$	-	0.3	(0.2,0.3,0.4)	((0.2,0.3,0.4;1),(0.25,0.3,0.35;0.8))
$C_3 \rightarrow C_7$	-	0.25	(0.15,0.25,0.35)	((0.15,0.25,0.35;1),(0.2,0.25,0.30;0.8))
$C_4 \rightarrow C_5$	-	0.4	(0.3,0.4,0.5)	((0.3,0.4,0.5;1),(0.35,0.4,0.45;0.8))
$C_4 \rightarrow C_7$	-	0.3	(0.2,0.3,0.4)	((0.2,0.3,0.4;1),(0.25,0.3,0.35;0.8))
$C_5 \rightarrow C_4$	-	0.3	(0.2,0.3,0.4)	((0.2,0.3,0.4;1),(0.25,0.3,0.35;0.8))
$C_5 \rightarrow C_7$	+	0.6	(0.5,0.6,0.7)	((0.5,0.6,0.7;1),(0.55,0.6,0.65;0.8))
$C_6 \rightarrow C_2$	+	0.55	(0.3,0.55,0.8)	((0.3,0.55,0.8;1),(0.35,0.55,0.75;0.8))
$C_6 \rightarrow C_7$	+	0.5	(0.25,0.5,0.75)	((0.25,0.5,0.75;1),(0.3,0.5,0.7;0.8))
$C_7 \rightarrow C_1$	+	0.3	(0.05,0.3,0.55)	((0.05,0.3,0.55;1),(0.1,0.3,0.5;0.8))
$C_7 \rightarrow C_2$	+	0.7	(0.45,0.7,0.95)	((0.45,0.7,0.95;1),(0.5,0.7,0.9;0.8))
$C_7 \rightarrow C_5$	+	0.55	(0.45,0.55,0.65)	((0.45,0.55,0.65;1),(0.5,0.55,0.6;0.8))

Table S.5 Initial concept values in radiotherapy planning model

	Scenario 1			Scenario 2		
Concept	**Crisp**	**T1 fuzzy**	**IT2 fuzzy**	**Crisp**	**T1 fuzzy**	**IT2 fuzzy**
C1	0.75	(0.75,0.75,0.75)	(0.75,0.75,0.75;1) (0.75,0.75,0.75;1)	0.80	(0.6,0.8,1)	((0.6,0.8,1;1), (0.65,0.8,0.95;0.8))
C2	0.8	(0.80,0.80,0.80)	(0.80,0.80,0.80;1) (0.80,0.80,0.80;1)	0.85	(0.7,0.85,1)	((0.7,0.85,1;1), (0.75,0.85,0.95;0.8))
C3	0.3	(0.3,0.3,0.3)	(0.3,0.3,0.3;1) (0.3,0.3,0.3;1)	0.25	(0,0.25,0.5)	((0,0.25,0.5;1), (0.05,0.25,0.45;0.8))
C4	0.6	(0.6,0.6,0.6)	(0.6,0.6,0.6;1) (0.6,0.6,0.6;1)	0.45	(0.3,0.45,0.6)	((0.3,0.45,0.6;1), (0.35,0.45,0.55;0.8))
C5	0.7	(0.7,0.7,0.7)	(0.7,0.7,0.7;1) (0.7,0.7,0.7;1)	0.60	(0.5,0.6,0.7)	((0.5,0.6,0.7;1), (0.55,0.6,0.65;0.8))
C6	0.5	(0.5,0.5,0.5)	(0.5,0.5,0.5;1) (0.5,0.5,0.5;1)	0.55	(0.4,0.55,0.7)	((0.4,0.55,0.7;1), (0.45,0.55,0.65;0.8))
C7	0.65	(0.65,0.65,0.65)	(0.65,0.65,0.65;1) (0.65,0.65,0.65;1)	0.25	(0,0.25,0.5)	((0,0.25,0.5;1), (0.25,0.25,0.45;0.8))

Table S.6 Simulation results of radiotherapy planning model with hyperbolic tangent function

		Scenario 1			Scenario 2		
λ	**Concept**	**Crisp**	**T1 fuzzy**	**IT2 fuzzy**	**Crisp**	**T1 fuzzy**	**IT2 fuzzy**
1.0	C1	0.901	(0.598,0.901,0.967)	((0.598,0.901,0.967;1), (0.719,0.901,0.959;0.8))	0.901	(0.598,0.901,0.967)	((0.598,0.901,0.967;1), (0.719,0.901,0.959;0.8))
	C2	0.926	(0.861,0.926,0.958)	((0.861,0.926,0.958;1), (0.879,0.926,0.953;0.8))	0.927	(0.861,0.926,0.959)	((0.861,0.926,0.959;1), (0.879,0.926,0.953;0.8))
	C3	0.031	(0.031,0.031,0.031)	((0.031,0.031,0.031;1), (0.031,0.031,0.031;0.8))	0.000	(0,0.031,0.031)	((0,0.031,0.031;1), (0.026,0.031,0.031;0.8))
	C4	-0.792	(-0.842,-0.792,-0.716)	((-0.842,-0.792,-0.716;1), (-0.819,-0.792,-0.758;0.8))	-0.792	(-0.842,-0.792,-0.716)	((-0.842,-0.792,-0.716;1), (-0.819,-0.792,-0.758;0.8))
	C5	0.948	(0.917,0.948,0.966)	((0.917,0.948,0.966;1), (0.935,0.948,0.958;0.8))	0.948	(0.917,0.948,0.966)	((0.917,0.948,0.966;1), (0.935,0.948,0.958;0.8))
	C6	0.031	(0.031,0.031,0.031)	((0.031,0.031,0.031;1), (0.031,0.031,0.031;0.8))	0.031	(0.031,0.031,0.031)	((0.031,0.031,0.031;1), (0.031,0.031,0.031;0.8))
	C7	0.993	(0.978,0.993,0.997)	((0.978,0.993,0.997;1), (0.987,0.993,0.996;0.8))	0.993	(0.978,0.993,0.997)	((0.978,0.993,0.997;1), (0.987,0.993,0.996;0.8))
3.0	C1	1.000	(0.997,1,1)	((0.997,1,1;1), (0.998,1,1;0.8))	1.000	(0.997,1,1)	((0.997,1,1;1),(0.998,1,1;0.8))
	C2	1.000	(0.999,1,1)	((0.999,1,1;1),(1,1,1;0.8))	1.000	(0.999,1,1)	((0.999,1,1;1),(1,1,1;0.8))
	C3	0.995	(0.995,0.995,0.995)	((0.995,0.995,0.995;1), (0.995,0.995,0.995;0.8))	0.000	(0,0.995,0.995)	((0,0.995,0.995;1), (0.995,0.995,0.995;0.8))
	C4	0.963	(0.911,0.963,0.982)	((0.911,0.963,0.982;1), (0.945,0.963,0.975;0.8))	0.963	(-1,0.963,0.982)	((-1,0.963,0.982;1), (-0.999,0.963,0.975;0.8))
	C5	0.998	(0.993,0.998,0.999)	((0.993,0.998,0.999;1), (0.997,0.998,0.999;0.8))	0.998	(0.993,0.998,1)	((0.993,0.998,1;1), (0.997,0.998,1;0.8))
	C6	0.995	(0.995,0.995,0.995)	((0.995,0.995,0.995;1), (0.995,0.995,0.995;0.8))	0.995	(0.995,0.995,0.995)	((0.995,0.995,0.995;1), (0.995,0.995,0.995;0.8))
	C7	1.000	(1,1,1)	((1,1,1;1),(1,1,1;0.8))	1.000	(1,1,1)	((1,1,1;1),(1,1,1;0.8))
5.0	C1	1.000	(1,1,1)	((1,1,1;1),(1,1,1;0.8))	1.000	(1,1,1)	((1,1,1;1),(1,1,1;0.8))
	C2	1.000	(1,1,1)	((1,1,1;1),(1,1,1;0.8))	1.000	(1,1,1)	((1,1,1;1),(1,1,1;0.8))
	C3	1.000	(1,1,1)	((1,1,1;1),(1,1,1;0.8))	0.000	(0,1,1)	((0,1,1;1),(1,1,1;0.8))
	C4	0.998	(0.995,0.998,0.999)	((0.995,0.998,0.999;1), (0.997,0.998,0.999;0.8))	0.998	(-1,0.998,0.999)	((-1,0.998,0.999;1), (0.997,0.998,0.999;0.8))
	C5	1.000	(1,1,1)	((1,1,1;1),(1,1,1;0.8))	1.000	(1,1,1)	((1,1,1;1),(1,1,1;0.8))
	C6	1.000	(1,1,1)	((1,1,1;1),(1,1,1;0.8))	1.000	(1,1,1)	((1,1,1;1),(1,1,1;0.8))
	C7	1.000	(1,1,1)	((1,1,1;1),(1,1,1;0.8))	1.000	(1,1,1)	((1,1,1;1),(1,1,1;0.8))

Table S.7 Simulation results of radiotherapy planning model with sigmoid function

		Scenario 1			Scenario 2		
λ	**Concept**	**Crisp**	**T1 fuzzy**	**IT2 fuzzy**	**Crisp**	**T1 fuzzy**	**IT2 fuzzy**
1.0	C1	0.787	(0.681,0.787,0.868)	((0.681,0.787,0.868;1), (0.704,0.787,0.854;0.8))	0.787	(0.681,0.787,0.868)	((0.681,0.787,0.868;1), (0.704,0.787,0.854;0.8))
	C2	0.837	(0.739,0.837,0.9)	((0.739,0.837,0.9;1), (0.768,0.837,0.887;0.8))	0.837	(0.739,0.837,0.9)	((0.739,0.837,0.9;1), (0.768,0.837,0.887;0.8))
	C3	0.659	(0.659,0.659,0.659)	((0.659,0.659,0.659;1), (0.659,0.659,0.659;0.8))	0.659	(0.659,0.659,0.659)	((0.659,0.659,0.659;1), (0.659,0.659,0.659;0.8))
	C4	0.592	(0.563,0.592,0.619)	((0.563,0.592,0.619;1), (0.578,0.592,0.606;0.8))	0.592	(0.563,0.592,0.619)	((0.563,0.592,0.619;1), (0.578,0.592,0.606;0.8))
	C5	0.729	(0.675,0.729,0.772)	((0.675,0.729,0.772;1), (0.702,0.729,0.752;0.8))	0.729	(0.675,0.729,0.772)	((0.675,0.729,0.772;1), (0.702,0.729,0.752;0.8))
	C6	0.659	(0.659,0.659,0.659)	((0.659,0.659,0.659;1), (0.659,0.659,0.659;0.8))	0.659	(0.659,0.659,0.659)	((0.659,0.659,0.659;1), (0.659,0.659,0.659;0.8))
	C7	0.902	(0.815,0.902,0.949)	((0.815,0.902,0.949;1), (0.854,0.902,0.934;0.8))	0.902	(0.815,0.902,0.949)	((0.815,0.902,0.949;1), (0.854,0.902,0.934;0.8))
3.0	C1	0.992	(0.96,0.992,0.998)	((0.96,0.992,0.998;1), (0.971,0.992,0.998;0.8))	0.992	(0.96,0.992,0.998)	((0.96,0.992,0.998;1), (0.971,0.992,0.998;0.8))
	C2	0.997	(0.982,0.997,0.999)	((0.982,0.997,0.999;1), (0.989,0.997,0.999;0.8))	0.997	(0.982,0.997,0.999)	((0.982,0.997,0.999;1), (0.989,0.997,0.999;0.8))
	C3	0.944	(0.944,0.944,0.944)	((0.944,0.944,0.944;1), (0.944,0.944,0.944;0.8))	0.944	(0.944,0.944,0.944)	((0.944,0.944,0.944;1), (0.944,0.944,0.944;0.8))
	C4	0.837	(0.736,0.837,0.892)	((0.736,0.837,0.892;1), (0.795,0.837,0.868;0.8))	0.837	(0.736,0.837,0.892)	((0.736,0.837,0.892;1), (0.795,0.837,0.868;0.8))
	C5	0.972	(0.945,0.972,0.986)	((0.945,0.972,0.986;1), (0.961,0.972,0.98;0.8))	0.972	(0.945,0.972,0.986)	((0.945,0.972,0.986;1), (0.961,0.972,0.98;0.8))
	C6	0.944	(0.944,0.944,0.944)	((0.944,0.944,0.944;1), (0.944,0.944,0.944;0.8))	0.944	(0.944,0.944,0.944)	((0.944,0.944,0.944;1), (0.944,0.944,0.944;0.8))
	C7	1.000	(0.997,1,1)	((0.997,1,1;1),(0.999,1,1;0.8))	1.000	(0.997,1,1)	((0.997,1,1;1),(0.999,1,1;0.8))
5.0	C1	1.000	(0.996,1,1)	((0.996,1,1;1),(0.997,1,1;0.8))	1.000	(0.996,1,1)	((0.996,1,1;1),(0.997,1,1;0.8))
	C2	1.000	(0.999,1,1)	((0.999,1,1;1),(0.999,1,1;0.8))	1.000	(0.999,1,1)	((0.999,1,1;1),(0.999,1,1;0.8))
	C3	0.993	(0.993,0.993,0.993)	((0.993,0.993,0.993;1), (0.993,0.993,0.993;0.8))	0.993	(0.993,0.993,0.993)	((0.993,0.993,0.993;1), (0.993,0.993,0.993;0.8))
	C4	0.966	(0.936,0.966,0.98)	((0.936,0.966,0.98;1), (0.953,0.966,0.974;0.8))	0.966	(0.936,0.966,0.98)	((0.936,0.966,0.98;1), (0.953,0.966,0.974;0.8))
	C5	0.997	(0.991,0.997,0.999)	((0.991,0.997,0.999;1), (0.995,0.997,0.998;0.8))	0.997	(0.991,0.997,0.999)	((0.991,0.997,0.999;1), (0.995,0.997,0.998;0.8))
	C6	0.993	(0.993,0.993,0.993)	((0.993,0.993,0.993;1), (0.993,0.993,0.993;0.8))	0.993	(0.993,0.993,0.993)	((0.993,0.993,0.993;1), (0.993,0.993,0.993;0.8))
	C7	1.000	(1,1,1)	((1,1,1;1),(1,1,1;0.8))	1.000	(1,1,1)	((1,1,1;1),(1,1,1;0.8))