Prediction of severe driving conditions in winter

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ROADIDEA

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Inteligentni sistemi, senzorji in novi materiali
Intelligent systems, sensors and new materials
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Objectives

- **Problem:** Statistical estimation of relation between measured environmental variables and driving conditions in winter.
- **Basis for treatment:** Experimentally estimated probability density function - PDF.
- **Extraction of a relation:** General regression expressed by the conditional average estimator - CA.
- **Goal:** To provide data for optimization of winter roads service by intelligent control.

Experimental basis

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- A vector variable $Z = (X, Y)$ is utilized to join data about environment - X, and driving conditions - Y.

- Calibration by units u and v yields the joint instrument scattering function

$$w(z,w;\sigma) = w(x,u;\sigma)\,w(y,v;\sigma)$$

σ is assumed to be equal for all components

Statistical basis
the joint probability density - PDF

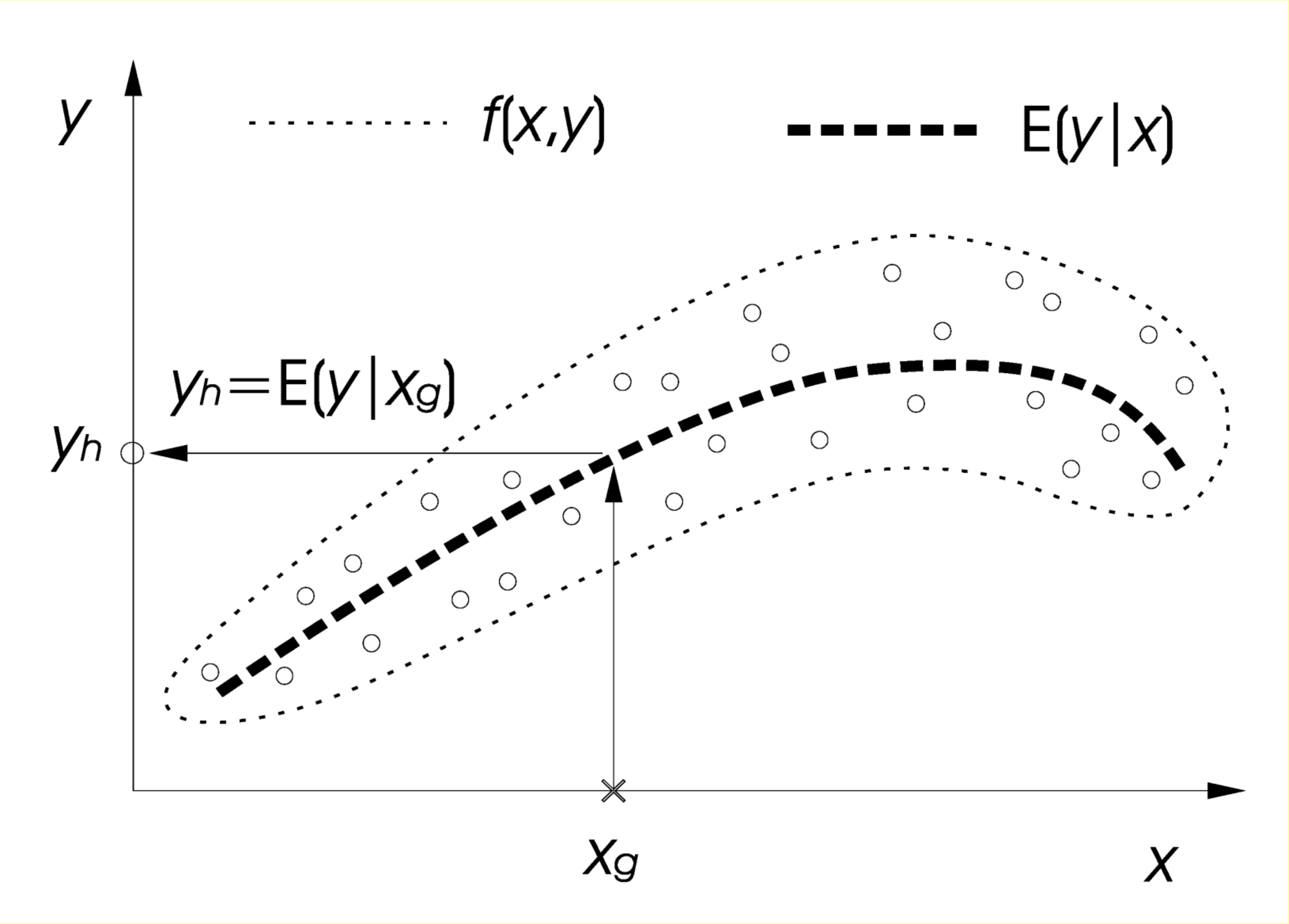
N measured joint data $z_1, \ldots, z_N$ are given

$$f(x,y) = \frac{1}{N} \sum_{i=1}^{N} w(x, x_i; \sigma)\, w(y, y_i; \sigma)$$

w denotes normal probability distribution

σ is the mean distance between data points

Statistical estimation of hidden driving conditions Y_h from given weather data X_g



Extraction of relation *Y*(*x*) from PDF

Optimal predictor is the conditional average:

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$$Y_p(x) = \mathrm{E}\left[\, y \,|\, x \,\right] = \int y\, f(y|x)\, dy$$

Expressed by data it gets the form:

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$$Y_p(x) = \frac{\sum_{i=1}^{N} y_i\, w(x - x_i;\sigma)}{\sum_{j=1}^{N} w(x - x_j;\sigma)} = \sum_{i=1}^{N} y_i\, S_i(x)$$

Properties of $S_i(x)$

$$S_i(x) = \frac{w(x - x_i; \sigma)}{\sum_{j=1}^{N} w(x - x_j; \sigma)}$$

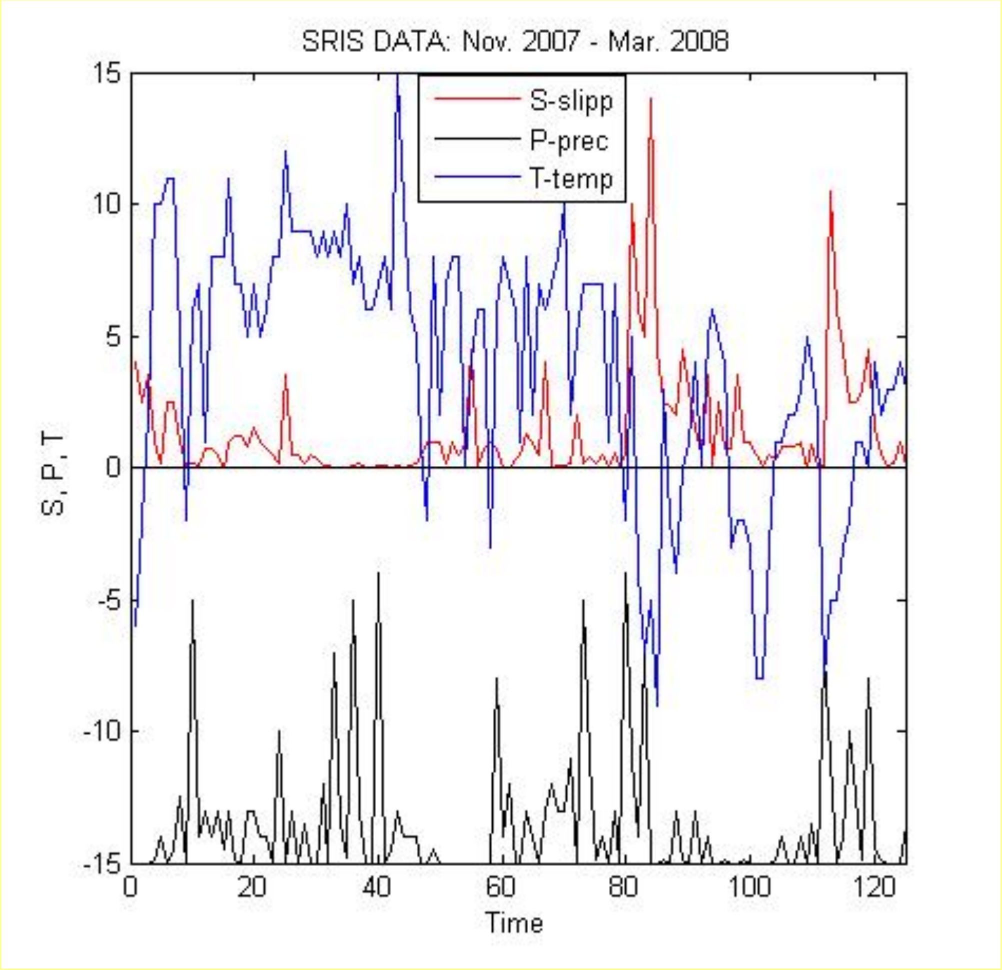
S_i is a normalized measure of similarity between given x and stored x_i

$$\sum_{i=1}^{N} S_i = 1 \qquad\qquad 0 \le S_i \le 1$$

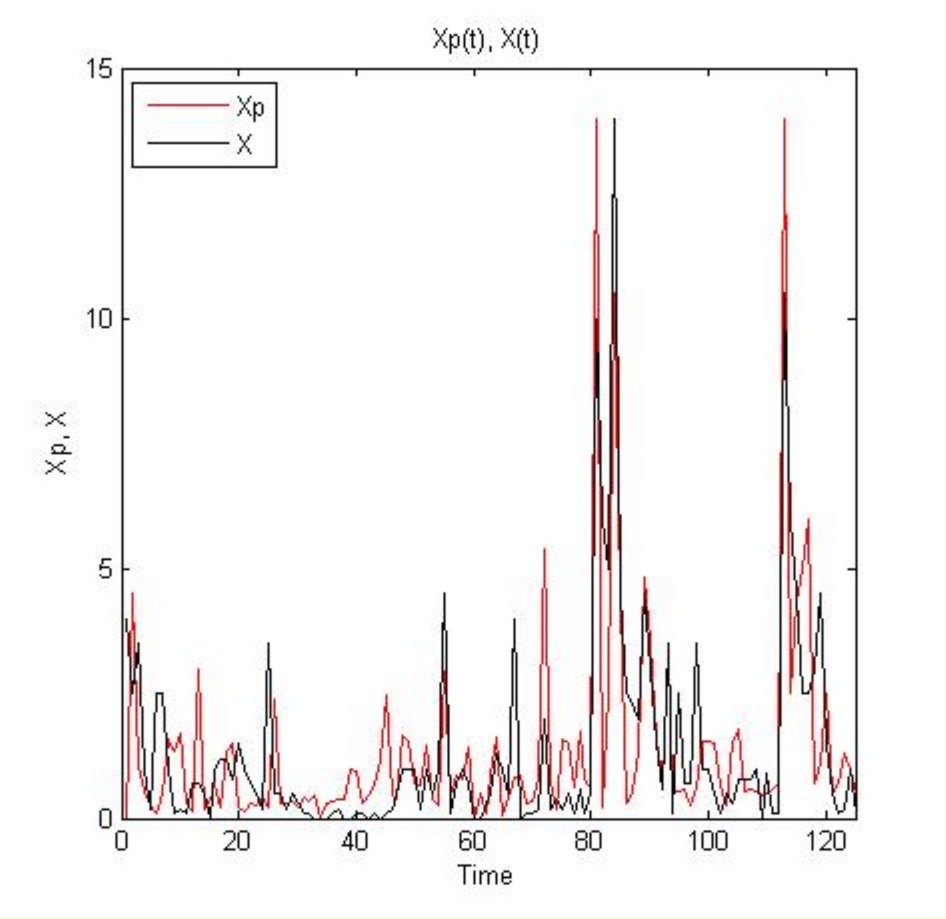
Prediction of road slipperiness from weather forecasts in Sweden

Data: S – Slipperiness
P – Precipitation,
T – Temperature,

Data provided by: Slippery road information system – SRIS - www.sris.nu



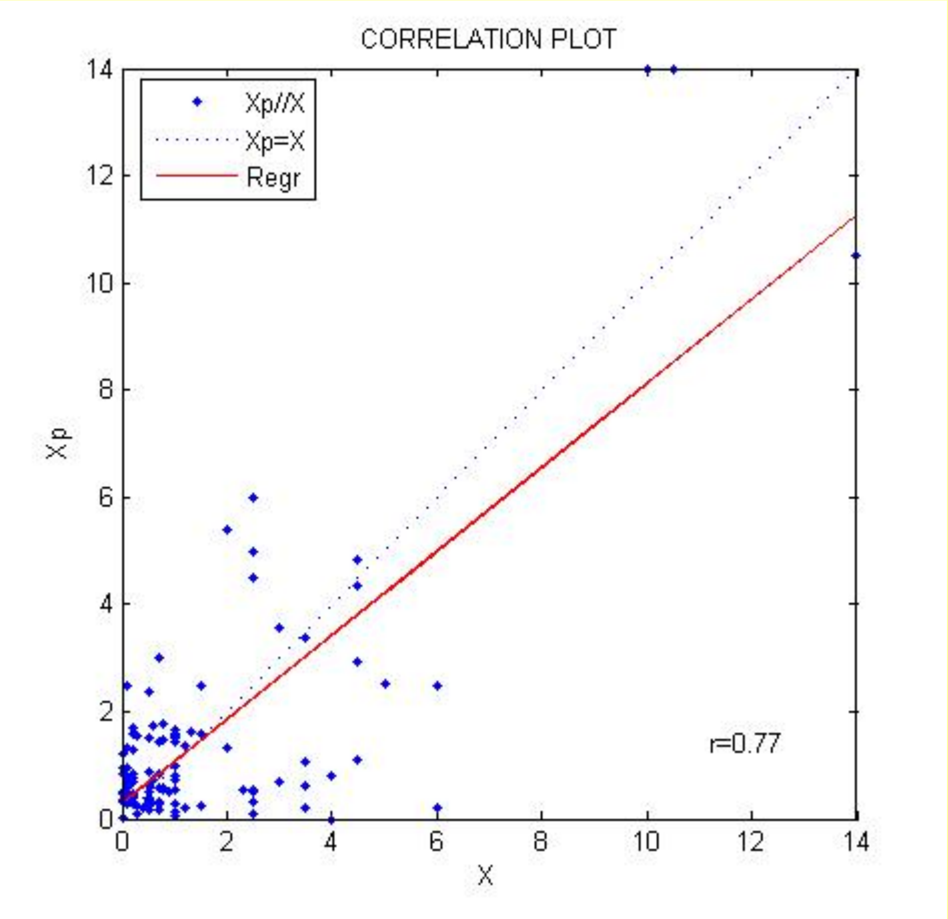
Predicted and original slipperiness



1 day ahead prediction

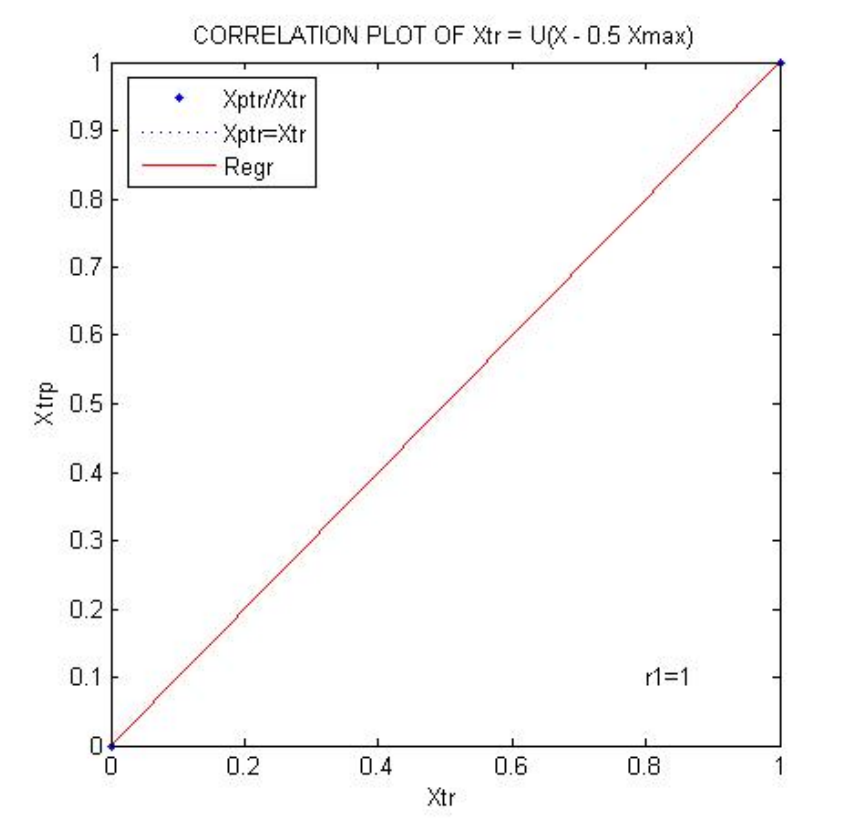
Accounting of past data improves accuracy of prediction

Correlation plot of X_p and actual X



r – correlation coefficient of X_p and X

Correlation plot of transformed critical variable: $X_{tr} = U(X - 0.5\ X_{max})$



r – correlation coefficient of X_{trp} and X_{tr}

Prediction of air pollution ARPV data about *PM10*

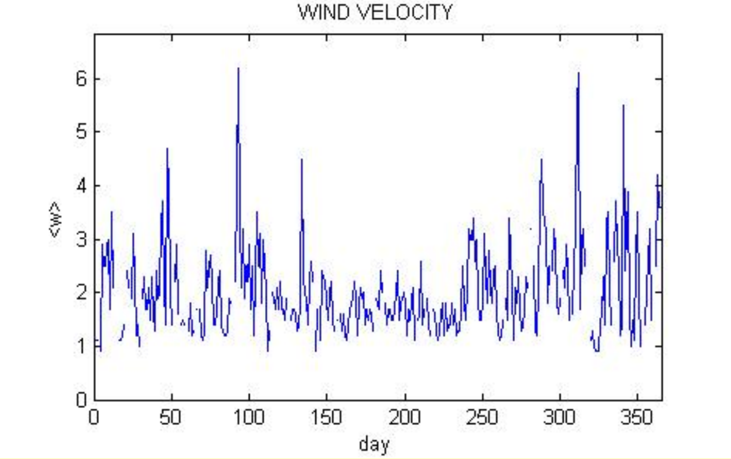
Microsoft Excel - Arpv_data

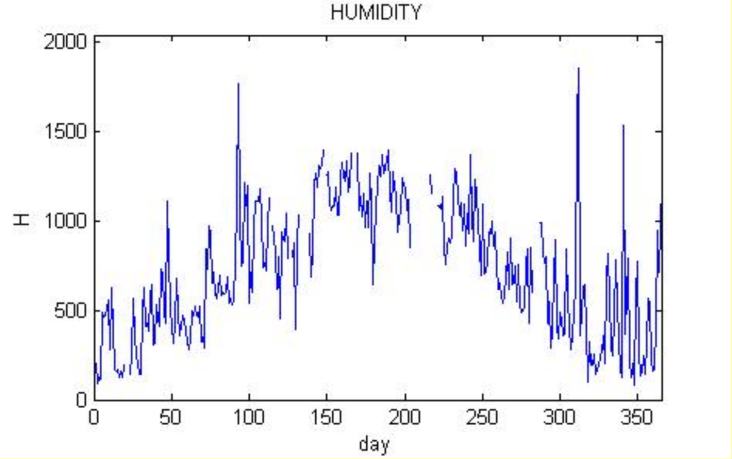
	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R	S	T
1		Percentage of wind calm <0.5 m/s	Average wind speed	Average wind speed (without values<0.5 m/s)	Average wind direction	Hmix rural	Hmix urban	Stanford Index	Average radiation	T minimum	Average T	Total precipitation	Equavalent potetial temperature	Concentration PM10 Air Quality Station in Arcella	Concentration PM10 in Air Quality Station in Mandia	Concentration PM10 in Air Quality Station. Average Mandria and Arcella				
2	date	% wind calm	vv_m	vvc_m	dv_m	zi_r	zi_u	stan_u	rmed	tmin	tmed	ptot	thte	PM10_arc	PM10_man	PM10_tipo		aa	mm	gg
3	1.1.2003	17	1	1 1	289,1	156	206	0,54	81	277	280	0	296	63	62	63,0		2003	1	1
4	2.1.2003	12	1	1 1	352,9	46	90	0,69	7	278	278	0,2	294	55	54	55,0		2003	1	2
5	3.1.2003	25	1		85,2	74	126	1,37	17	277	278	0	293	53	46	50,0		2003	1	3
6	4.1.2003	17	0,8	0 9	75,1	93	117	2,74	50	274	276	0,2	289	62	46	54,0		2003	1	4
7	5.1.2003	8	2,7	2 9	299,5	266	491	0,39	31	276	278	5,8	293	44	40	42,0		2003	1	5
8	6.1.2003	8	2,3	2 5	326	262	464	0,05	42	274	276	8	288	48	36	42,0		2003	1	6
9	7.1.2003	0	2,5	2 5	338,2	245	471	0	19	274	275	5	287	33	25	29,0		2003	1	7
10	8.1.2003	0	2,9	2 9	336,4	271	521	0	12	274	275	0,2	285		41	41,0		2003	1	8
11	9.1.2003	0	3	3	334,6	285	553	0,02	28	273	274		301		32	32,0		2003	1	9
12	10.1.2003	12	1,5	1 7	337,2	188	284	0	51	273	274	0	289					2003	1	10
13	11.1.2003	0	3,5	3 5	323,2	347	623	0,03	87	272	274	0	298					2003	1	11
14	12.1.2003	4	2,1	2 1	357,9	257	391	0,36	100	269	272	0	302					2003	1	12
15	13.1.2003	37	0,7		57,1	136	178	2,75	83	267	271	0	311		130	130,0		2003	1	13
16	14.1.2003	62	0,5		41	119	156	1,81	84	269	273	0,2	314		152	152,0		2003	1	14
17	15.1.2003	62	0,5		14,4	125	166	5,1	80	270	273	0,2	315		188	188,0		2003	1	15
18	16.1.2003	8	1	1 1	12	91	126	4,98	46	270	274	0,2	305		196	196,0		2003	1	16
19	17.1.2003	17	0,9	1 1	41,7	120	163	3,54	72	272	276	0	300		127	127,0		2003	1	17
20	18.1.2003	17	1,1	1 2	34,8	84	124	1,43	39	272	277	0	291	128	103	116,0		2003	1	18
21	19.1.2003	0	1,4	1 4	68,7	156	198	4,08	105	271	274	0,2	318	76	67	72,0		2003	1	19
22	20.1.2003	33	0,7		78,4				93	271	275	0,4	306	101	97	99,0		2003	1	20
23	21.1.2003	4	2,3	2 4	312,2				17	276	278	15	293	83	87	85,0		2003	1	21
24	22.1.2003	17	1,8	2 1	39,8				31	275	279	2	294	49	50	50,0		2003	1	22
25	23.1.2003	37	0,8		70	112	141	2,39	56	273	277	0,2	296	84	73	79,0		2003	1	23
26	24.1.2003	0	1,9	1 9	339,7	170	258	2,17	107	274	279	0	291	67	52	60,0		2003	1	24
27	25.1.2003	0	3,1	3 1	326,3	331	566	1,22	108	277	279	0,2	290	49	37	43,0		2003	1	25
28	26.1.2003	0	2,3	2 3	335,9	268	365	2,23	111	275	278	0	288		47	47,0		2003	1	26
29	27.1.2003	4	1,1	1 2	66,4	192	245	3,29	96	273	277	0	294		86	86,0		2003	1	27
30	28.1.2003	12	1,2	1 4	0,4	141	200	2,63	87	272	276	0	303	148	134	141,0		2003	1	28

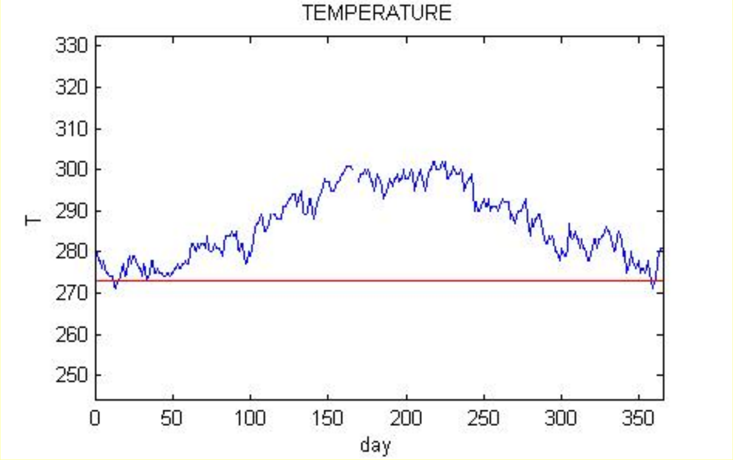
Selection of variables used in modelling predictor of *PM10*

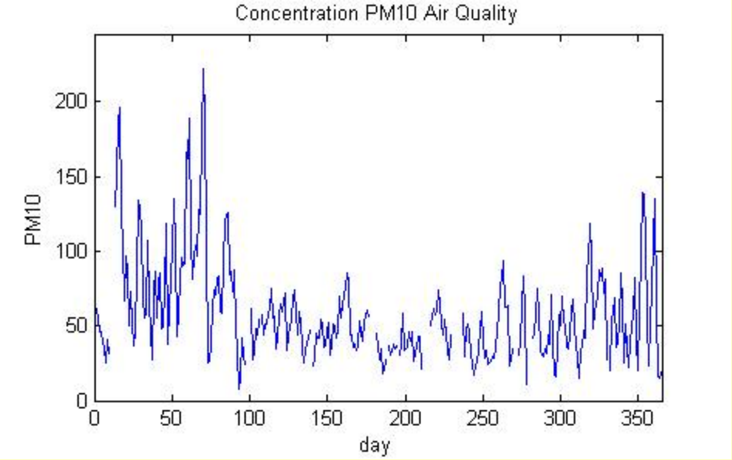
- As given variables we consider: the average wind velocity - *W*, humidity – *H* and average temperature – *T*.
- As hidden variables we consider concentration *P=PM10*.
- Using sample vectors $\mathbf{Z}_i = (W,H,T,P)$ *from* the data base we create statistical model of the relation *P=G(W,H,T)* by the CA estimator.
- By using the model we predict hidden *P* from some given data *W,H,T*.
- Here the time is used as sample index *i*.
- Agreement between predicted and really measured data is described by the correlation coefficient *r* and shown in a correlation diagram.

Variables used in modelling

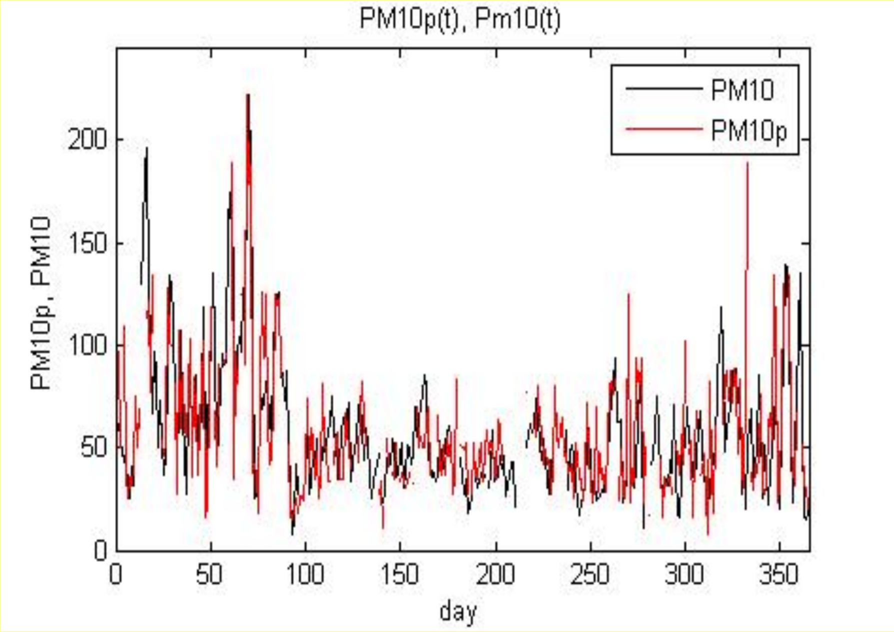


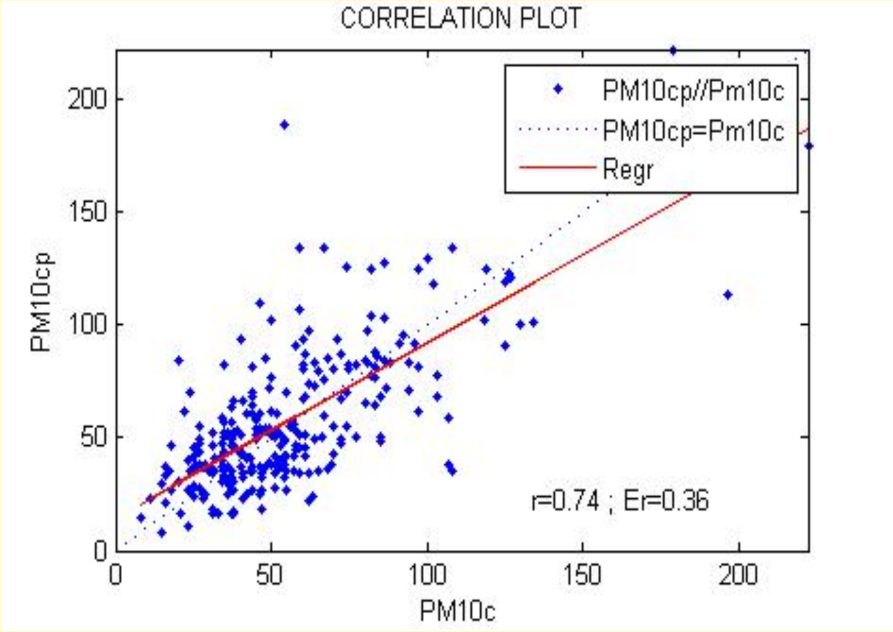




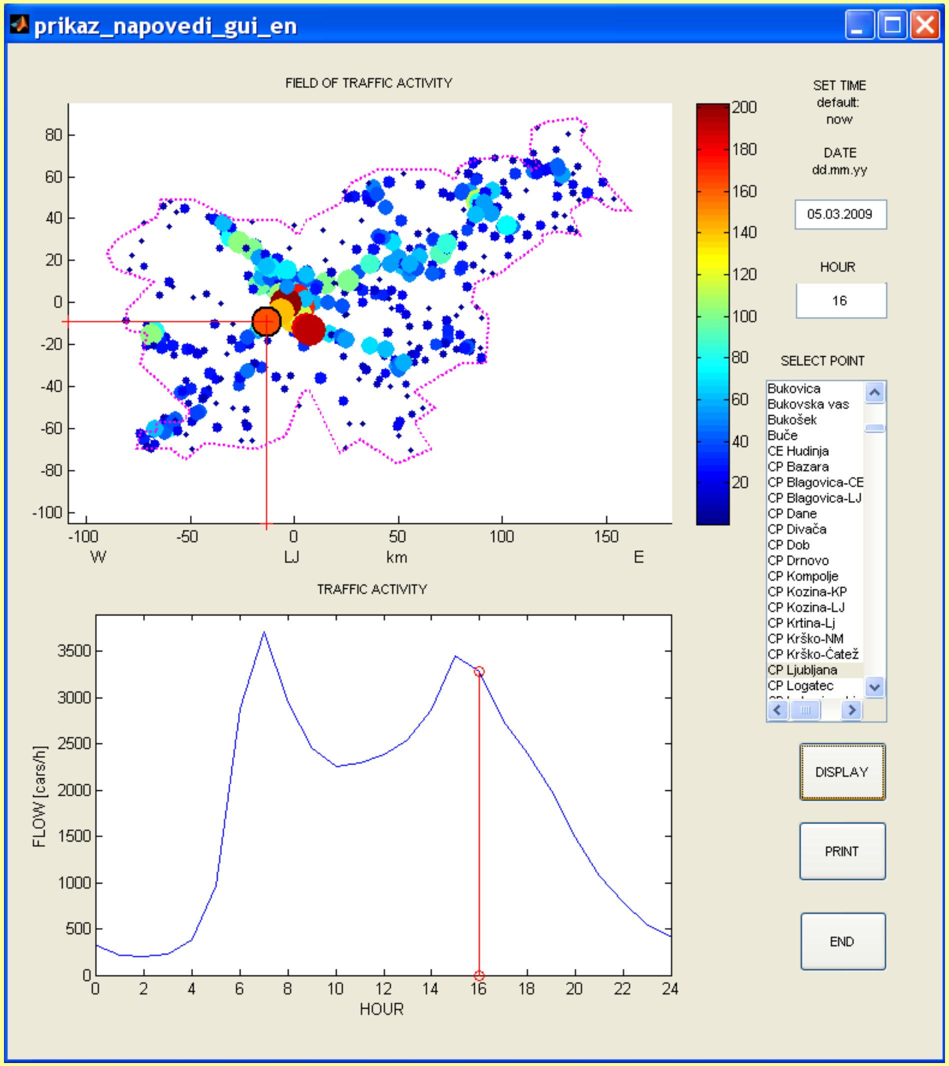


Results of prediction





Graphic user interface for display of predicted traffic activity in Slovenia



- User sets time – day and hour - of prediction in the interval from now to the year 2015.
- From the pop-up menu an observation point is selected.
- GUI displays the field of traffic activity from the start of the selected day to the selected hour in the top graph.
- GUI displays the distribution of predicted traffic flow over the selected day in the bottom graph.
- The selected place and hour of prediction are marked in graphs.
- The prediction can be repeated with varied time and place.
- The display can be printed.

Coclusions

- Our approach to prediction of driving conditions needs no analytical model, but extracts it from experimental data.
- The same approach was successfully applied also to forecasting of traffic flows.
- The method provides information support for planning of winter roads service.
- The next step is an approch to intelligent control of winter roads service.

References

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