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Evaluation of Road Safety in Portugal: A Case Study Analysis

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OUTLINE

- Objectives
- Methodology
- Results
  - Road environments
  - Expected number of road accidents
- Conclusions

OBJECTIVES

- PhD Research at Technical University of Lisbon
- Definition of different maintenance programmes for skid resistance and texture depth in different road environments
  1. Selection of roads
  2. Definition of road environments
  3. Modelling the expected value of road accidents
     a. Evaluation of the influence of pavement surface characteristics on accident occurrence
     b. Establishing threshold values for the International Friction Index (IFI), skid resistance and texture depth, according to safety criteria

METHODOLOGY (I)

1. SELECTION OF ROADS

Sample Process

→ **Sample Universe**
Portuguese Road Network
Sample Subset
Primary and secondary roads, except motorways

→ **Sample Process**
Sequential type of non-random sampling

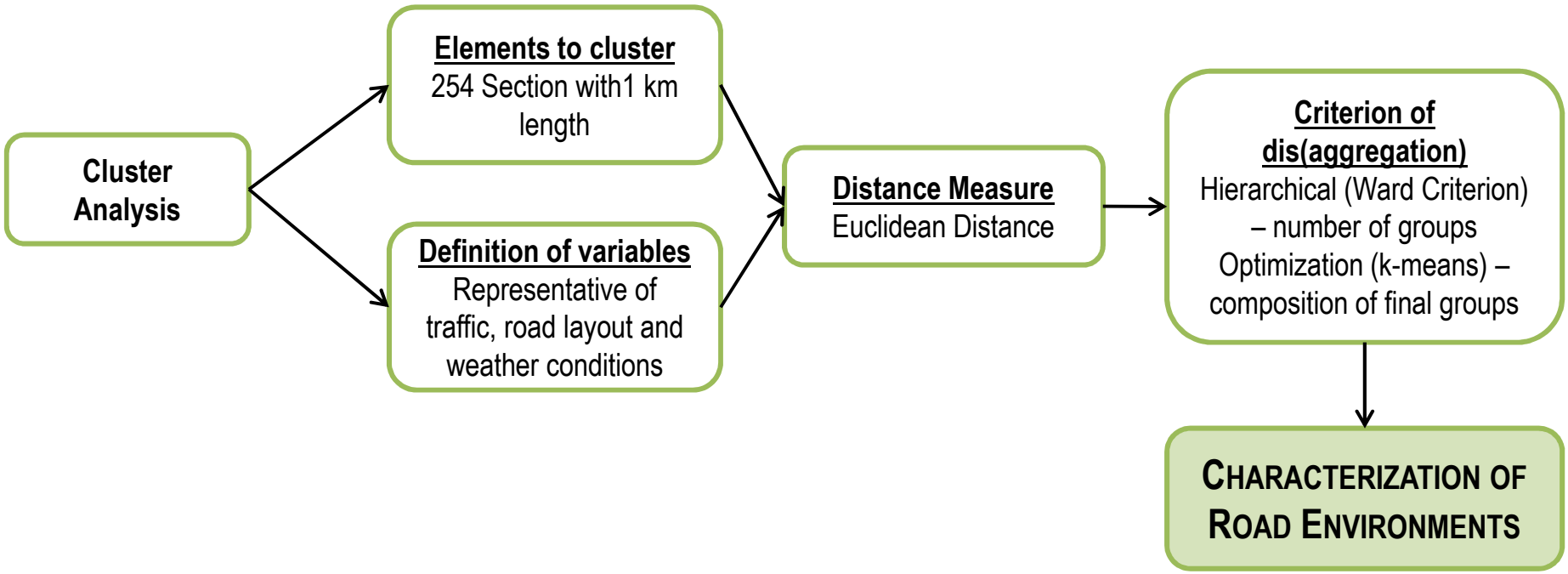
→ **Data acquisition**
Pavement condition surveys (Estradas de Portugal and University of Minho)

Historical data (accidents and precipitation) (Estradas de Portugal, Directorate-General for Traffic and Hydro Resources Information System)

→ **CHARACTERIZATION OF SELECTED ROADS**

METHODOLOGY (II)

2. DEFINITION OF ROAD ENVIRONMENTS



METHODOLOGY (III)

3. MODELLING THE EXPECTED NUMBER OF ROAD ACCIDENTS

Generalized Linear Models

Model components
Probability distribution:
Poisson
or
Negative Binomial
Linear Predictor:
Traffic, Road layout, Weather conditions and Pavement
Link function:
Logarithmic

Fitting
Calculation of model parameters
(Maximum-likelihood)
Coefficient of predictive variables and over-dispersion parameter

Selection of the Model
Predictive capacity of model
Omnibus Test
Pseudo-R^2
Statistical significance Test
Wald Test
Comparison between models
Log Maximum-likelihood
AIC/AICC/BIC/CAIC

- EVALUATION OF THE INFLUENCE OF PAVEMENT SURFACE CHARACTERISTICS ON ACCIDENT OCCURRENCE
- ESTABLISHING THRESHOLD VALUES FOR THE INTERNATIONAL FRICTION INDEX (IFI), SKID RESISTANCE AND TEXTURE DEPTH, ACCORDING TO SAFETY CRITERIA

RESULTS

SELECTED ROADS

- 8 different roads (A to H) with a total length of 254 km, covering:
  - different road categories,
  - varied geographical distribution,
  - good and bad levels of pavement conditions and accidents.

Road	Region	Category	Extension (km)
A	Lisboa	Secondary Road	19
B	Castelo Branco	Secondary Road	21
C	Beja	Primary road	43
D	Évora	Secondary Road	15
E	Faro	Secondary Road	39
F	Castelo Branco	Primary road	25
G	Vila Real	Primary road	52
H	Bragança	Primary road	40

RESULTS

ROAD ENVIRONMENTS

- 7 different road environments

Variables	Cluster 1 (RE1)	Cluster 2 (RE2)	Cluster 3 (RE3)	Cluster 4 (RE4)	Cluster 5 (RE5)	Cluster 6 (RE6)	Cluster 7 (RE7)	Mean	Standard Deviation
%H_TRAF	26%	4%	8%	7%	10%	9%	9%	10%	6%
AV_SP (km/h)	81	81	84	83	89	94	85	86	5
SP_85 (km/h)	90	90	94	92	91	101	93	94	4
%EXT_I	7,9%	29,2%	2,1%	3,8%	10,4%	7,3%	50,3%	11,7%	19,4%
%EXT_UZ	23%	87%	1%	1%	0%	0%	0%	7%	24%
EXT_C (m)	320	220	41	466	486	471	270	321	264
CL_C	2,3	1,8	0,1	2,2	3,0	2,3	1,7	1,8	1,5
CL_G	0,3	0,0	0,1	0,3	0,8	0,6	0,2	0,4	0,4
A_PREC (mm)	1058	735	591	693	1669	490	722	881	461
Nº of segments	19	15	63	38	55	39	25		

RESULTS

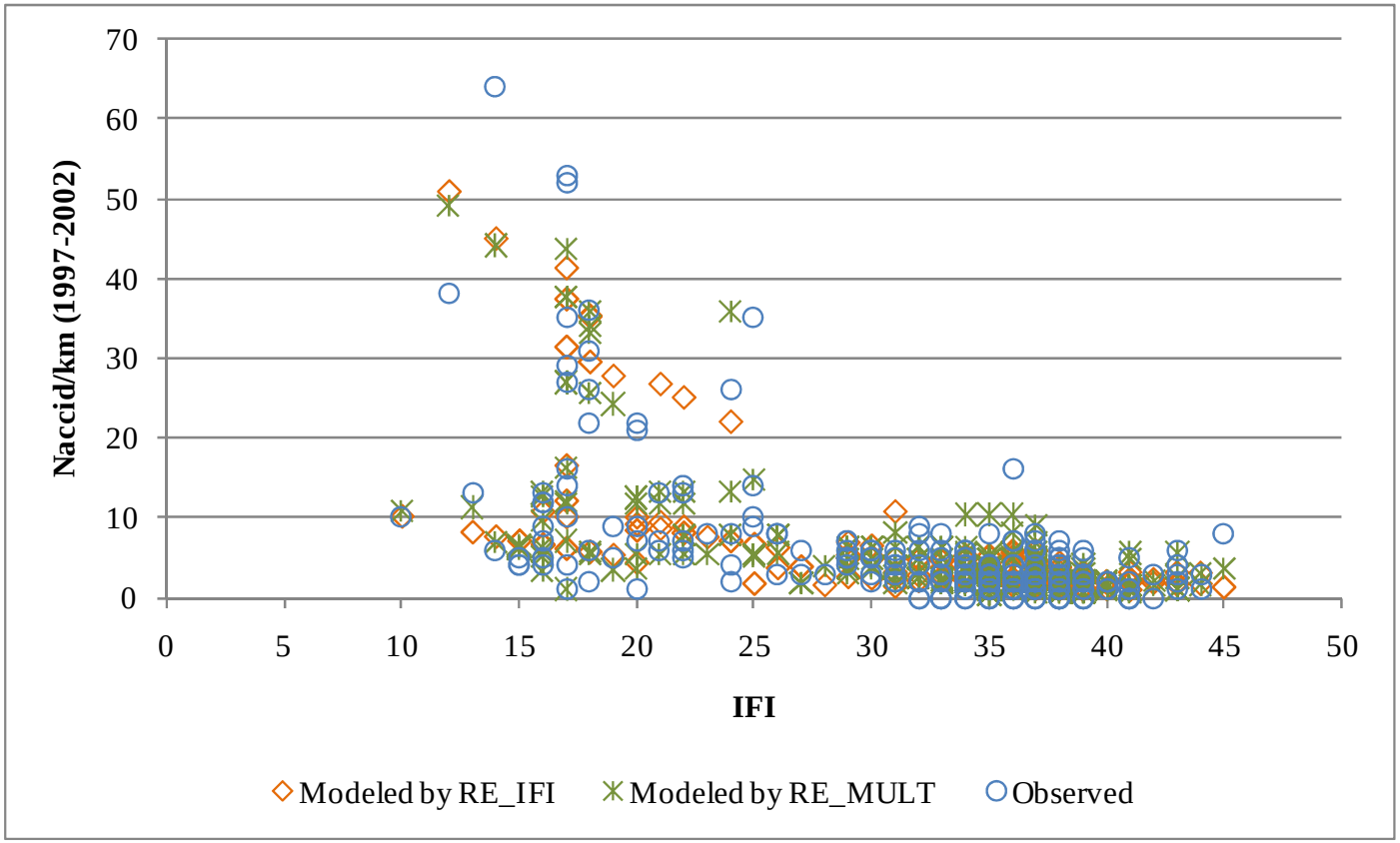
MODELLING THE EXPECTED NUMBER OF ROAD ACCIDENTS (I)

- Two different assumptions:
  - In each road environment, segments present homogeneous traffic conditions, road layout and precipitation, and regression was done with only one explanatory variable, the IFI: RE_IFI
  - In defining road environments, some characteristics were dominant, leading to some heterogeneity among the other variables. For this reason, the regression was made by introducing other explanatory variables into the model (i.e., the same variables used in the cluster analysis) – RE_MULT

$$N_{accid}/km = TRAF_{ACUM_i} \times \exp\left(\beta_0 + \beta_1 \times IFI_i + \beta_2 \times \%H_{TRAF_i} + \beta_3 \times AV\_SP_i + \beta_4 \times SP\_85_i + \beta_5 \times \%EXT\_UZ_i + \beta_6 \times \%EXT\_I_i + \beta_7 \times EXT\_C_i + \beta_8 \times CL\_C_i + \beta_9 \times CL\_G_i + \beta_{10} \times A\_PREC_i\right)$$

RESULTS

MODELLING THE EXPECTED NUMBER OF ROAD ACCIDENTS (II)



RESULTS

EVALUATION OF THE INFLUENCE OF PAVEMENT SURFACE CHARACTERISTICS ON ACCIDENT OCCURRENCE

- The influence of surface characteristics on accident occurrence was evaluated by analysing the coefficients associated with the explanatory variable IFI and measuring the impact that a change in IFI produces in the expected number of accidents.
- From this analysis, it was possible to conclude that there are, basically, three environments (E_i) where the pavement properties significantly, yet distinctly, influence the occurrence of accidents:
  - E_1: Rural environment with a heavy presence of urban characteristics – RE1 and RE2;
  - E_2: Environment characterised by a considerable predominance of intersections in a rural environment – RE7;
  - E_3: Environment with curved segments, high longitudinal gradients and average speed higher than the tolerable speed – RE6.

RESULTS

ESTABLISHING THRESHOLD VALUES FOR THE INTERNATIONAL FRICTION INDEX, SKID RESISTANCE AND TEXTURE DEPTH

	Minimum Values / Safety Values		
	IFI	Skid Resistance	Texture depth (mm)
E_1	20 / 25	40 / 50	0,4 / 0,5
E_2	25 / 28	45 / 55	0,4 / 0,5
E_3	30 / 33	50 / 60	0,5 / 0,6

CONCLUSIONS (I)

- A further scientific attempt to establish relationships between functional characteristics of pavement and road accidents by using a set of roads selected from the Portuguese road network.

- The cluster analysis used to identify different road environments is presented as innovative and a valid alternative for choosing the segments to be used in road accident prediction models.

- Weaknesses of cluster analysis: the groups formed are not, in most cases, completely homogeneous and there is some variation of characteristics within the same group, even if the variation within the group is less than between groups.

CONCLUSIONS (II)

- Problems with statistical significance, over-dispersion and reliability of accident data took place during the calibration process.

- Results show that road environments where braking manoeuvres are more common (E_1 and E_2) or those with small radii of curvature and high speeds (E_3) require higher skid resistance and texture depth levels.

- The Portuguese Highways Agency recently recognised the importance of research studies to support the development of maintenance programmes for surface characteristics to be incorporated into pavement management systems. This work seeks to contribute a set of values established according to safety criteria for skid resistance and texture depth maintenance.

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THANK YOU

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