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CANONICAL CORRELATION APPLIED TO THE FLOW OF VEHICULAR TRAFFIC

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ABSTRACT

The main goal of this study is to apply multivariate statistical analysis techniques to determine the accident's profile of Federal Highway BR-365, in the state of Minas Gerais, using database from traffic accidents that took place in 2011, in order to make a more appropriate planning, considering the miles identified as the most dangerous.
With the support of a database provided by the Federal Highway Police of Minas Gerais referring 1507 accidents occurred from January to December of 2011 at BR-365, the relationship of a set of variables was analyzed to define the accidents profile of these roads. The study was conducted with the extraction of qualitative variables from the database, to get the frequency matrix. Then the correlation matrix was used in the canonical correlation analysis to obtain the correlations between groups. The correlations' calculation between the canonical variables and original variables were made in order to verify which variables are most representative in their respective group.
Through the canonical correlation analysis it was observed that the studied groups are strongly correlated, meaning that the types of accidents have a canonical correlation of 1.00 with the causes of accidents, of 0.9935 with the time of day, of 0,9961 with the weather condition and of 0.9979 with the characteristics of the road. The identified profile is that rollovers that occurred on the highway had a high correlation with the factor of the driver does not respect the safety distance between vehicles, because it was night, the accidents also occurred when the sky was clear and the track was dry. Concerning vehicle side impact, a strong correlation with the lack of attention of the driver was observed, explained by correlation with the time of day, clear skies and track dryness. The reer collision was explained, again, by reason of failure to maintain the security distance, besides the period of the day, rain and wet track. The events related to lane departure are explained in his partiality for mechanical defects in the vehicle, night time, rain and wet track, although the correlation is not as high. The results may be used by the responsables of the highway in order to get a better planning of the changes that must be done, with the mainly goal of reducing the number of accidents.
There is in Brazil a great network of federal highways, with about 73mil km. The vehicle traffic on federal highways represents a phenomenon of great socioeconomic importance, mainly by the fact that it was the main way of transport used by society to move from one city to another. Representing, also, the most common alternative for products transport in Brazil. Increasing the number of the vehicles flow on the roads, it resulted on the rising number of accidents, making the lack of security an evident issue.

INTRODUCTION

The Brazilian automotive industry is undergoing a process of expansion, with increase of its production capacity, due to the significant volume of new investments. According to the AssociaçãoNacional dos Fabricantes de VeículosAutomotores - Brazil - ANFAVEA the Brazilian automotive industry produced 3.6 million units in 2011.

This growing fleet of vehicles occurs without proper improvement in the road system. Even with the use of resources is impossible and impractical to expand the routes to the same extent, because of the energy and environmental effects that would result. (MEIRELES, 2000).

Brazil has as its main means of production flow the road system. According to the Instituto de PesquisaEconômicaAplicada - IPEA. The highway concentrates 60% (sixty percent) of the volume of cargo transported in Brazil, that percentage is likely to grow in order to expand trade between the countries of Latin America. (IPEA, 2006).

However, the infrastructure of our highways, poor fleet of vehicles carrying loads, increasing the fleet and various other problems substantially favor the increased number of accidents, thus becoming a serious problem for public health.

The state of Minas Gerais has the largest road network in Brazil, about 35,960 km of paved and unpaved roads. These are 26,992 km state highways and 8,965 km are federal roads. (DER / MG).As a result, the traffic flow defined by (McSHANE and ROESS, 1990) as the number of vehicles passing on a section of track in a certain range or direction over a specific time interval, is constant and in large quantities, especially of heavy vehicles.

The flow of traffic on highways mining contributes to the high rate of accidents in the state. According to data from the DepartamentoNacional de Infraestrutura de Transportes- DNIT occurred 47,167 (forty-seven thousand one hundred and sixty seven) accidents on highways in Minas Gerais in 2010.

The increase in vehicular traffic on highways influences all variables accidents. According to World Health Organization (2001), are factors that contribute to the occurrence of vehicular accidents: human environmental risk factors and vehicular intrinsically linked (directly) to the transportation system and risk factors and socio-economic (indirect) which comes indirectly from broader structural issues arising from the organizational form of society.

Human factors involve actions that are associated with the vehicular driver, including excessive or inappropriate speed in a given situation; violation of laws, as well as aspects related to alcohol or drugs, lack of attention, decision-making errors; personal characteristics inherent to the driver, such as age, that may affect the way of driving the driver. Environmental factors include the design and track conditions; obstacles disposed off the traffic lane, traffic, weather, etc (Coelho, 1999). Factors vehicular represent any flaws that may exist in their own vehicle as well as design errors and design, poor maintenance etc. (DENATRAN, 2006). There is also a fourth element present in traffic accidents that is characterized by the involvement of socioeconomic evidenced in various forms, for example, unplanned urbanization, overloading the transit system; rapid motorization of society, without consideration of public investment in infrastructure (ORTUZAR*et al*,1996).

This study aims to confirm this correlation between the various factors related to accidents and the types of accidents in federal highway BR 365, using the statistical tool called multivariate canonical correlation. In intuit to determine the profile of these accidents in the studied year.

OBJECT OF STUDY

According to DNIT, the federal highways are those between two or more states and are built and maintained by the federal government. These receive a nomenclature the symbol BR, the first number indicates the category and the last two, the position of the road relative to Brasilia and boundaries of countries.

Roads may be defined as radial, longitudinal, transverse and diagonal. The BR 365, the object of this study is classified as a federal highway diagonal, for being willing to the northeast - southwest (DNIT, 2012th)

The BR-365 connects the two important cities of Minas Gerais: Montes Claros - Uberlândia, being a link between the Triangle and the North of Minas to Goiás, besides giving access to the highway Rio-Bahia and lead to major roadways from other neighboring states with Minas Gerais (MINAS GERAIS, 2012). The BR 365, currently is under public management, according to the report CNT (2011)

The highway passes through a duplication in the work of 79.3 km between Uberlândia and "Trevão" Ituiutaba sense. Begun in 2010, the work should be completed in February 2013. To date, nearly 50 km are duplicated (PÊGAS, 2012).

CANONICAL CORRELATION ANALYSIS

The goal of canonical correlation is to determine a linear combination for each group of variables maximizing the correlation between them (VESSONI, 1998).

According Vessoni (1998), one way to express a canonical correlation can be determined is a linear correlation between x and y maximizing the correlation Corr (U, V).

$$U = a_1 x_1 + a_2 x_2 + ... + a_n x_n$$

$$V = b_1 y_1 + b_2 y_2 + ... + b_n y_n$$

That is, suppose X being an *nxp* matrix and Y *nxq*

$$C = \text{cov}(X, Y)$$

It should separate this matrix C into four parts:

$$C = \begin{bmatrix} \sum_{pxp} {}_{11} & \sum_{pxq} {}_{12} \\ \sum_{qxp} {}_{21} & \sum_{qxq} {}_{22} \end{bmatrix}$$

The covariance between variables of different sets a variable X and one Y will be contained in (12) or (21). Analyzing the covariances in (12) or (21) can be extremely laborious, especially if *p* and *q* are large. However, the main objective of canonical correlation is to summarize the associations between X and Y according to some chosen few correlations, rather than correlations *pxq.*

Linear combination is a simple way of summarizing a set of variables

$$U = a'X$$
$$V = b'Y$$

$$Var(U) = a'Cov(X)a = a'\sum{}_{11}a$$
$$Var(V) = b'Cov(Y)b = b'\sum{}_{22}b$$
$$Cov(U,V) = a'Cov(X,Y)b = a'\sum{}_{12}b$$

The canonical correlation seeks to determine the vectors a and b such that it is as large as possible. There will min (p, q) -1 independent canonical variable pairs of the pair of maximum correlation, which will express the total variance of the two groups of variables.

$$Corr(U,V) = \frac{a'\sum{}_{12}b}{\sqrt{a'\sum{}_{11}a}\sqrt{b'\sum{}_{22}b}}$$

To calculate this maximum,

$$\max_{a,b} Corr(U,V) = \rho_1^*$$

Restricted by linear combination (first pair of canonical variables):

$$U_1 = \underbrace{e_1^{'}\sum{}_{11}^{-1/2}}_{a_1^{'}}X \quad e \quad V_1 = \underbrace{f_1^{'}\sum{}_{22}^{-1/2}}_{b_1^{'}}Y$$

In this case, ρ_1^{*2} is the eigenvalue of $\sum_{11}^{-1/2}\sum_{12}\sum_{22}^{-1}\sum_{11}\sum_{11}^{-1/2}$ and e_1 is the corresponding eigenvector.

The canonical correlation technique is often used in problems that have more than one metric dependent variable. The use of canonical correlation can simplify the problem and determine which variables are most important in the analysis. Analysis can be performed in two steps, first determining the relevant factors, and subsequently performing simple regressions between them.

The major limitation of this technique is the interpretation of the analysis. First, the canonical weights are derived to maximize the correlation between the linear compounds, not extracted variance. Second, canonical correlation reflects the shared variance between the linear compounds, not the extracted variance. The canonical correlation may therefore be high, even if the extracted variance is low. Finally, the canonical weights are subject to a high degree of instability, as in any other technique.

MATERIALS AND METHODS

The information recorded by the authorities of accidents are used in the composition of the databases. These banks allow statistical monitoring and testing aimed at diagnosing and proposing solutions for reducing accidents. Ideally, the record must contain a set of basic information that allows recognition of groups and places of higher risk as well as their interrelationship.

The methodology used in this study is grounded in the study by Bogo (2011) in his dissertation submitted to the Postgraduate Course on Numerical Methods in Engineering, Federal University of Paraná, Bogo uses the technique of Canonical Correlation to analyze accidents occurred in the BR-116, between January 2007 and November 2011. The database used was provided by the Federal Highway Police Department (2012), this is the record of the 1507 accident in detailed types of accidents, causes, road conditions, weather and stage of the day recorded at the time of the accident.

Following the methodology of Bogo (2011), the database has been treated to provide a table of frequencies of accidents per kilometer of highway, this will be the basis for the canonical correlation analysis.

For the analysis it was defined the response variables and the decision variables were not considered all types of accidents in the construction of the model, being removed from the analysis those whose occurrence was sporadic.

The decision variables were separated into groups, given their different characteristics: cause, weather conditions and so on. Being these groups analyzed one by one toward the group of variables response, as done in the methodology of Bogo (2011).

For Canonical Correlation analyzes, it was used the software BioStat 5.3.

RESULTS OF ANALYSIS OF CANONICAL CORRELATION

This topic presents the results in the application of Canonical Correlation Analysis, in each groups of decision variables.

Types of accidents X Causes of accidents

The first analysis refers to groups types of accidents X causes of accidents shown in Table 1.

Table 1: Results of the application of canonical correlation to Types of Accidents X Causes of Accidents

Canonical Variable	R canonical	R2 canonical	Qui-square	GL	p-value
1	1.0000	1.0000	326.4514	44	< 0.0001
2	0.9999	0.9998	90.9311	30	< 0.0001
3	0.9710	0.9429	31.7778	18	0.0234
4	0.9017	0.8131	11.7396	8	0.1632

Observing the results of the p-value, has two (2) Statistically significant canonical correlations. Analyzing further the eigenvalues (R), as well as its canonical correlation (R2) values for the first canonical variable (1.00) are absolute and are more significant than others.

The first canonical variable of the first set of variables as is understood as:

$U_1= 0{,}1933.\ X_1+0{,}8343.\ X_2+0{,}7689.\ X_3+0{,}7955.\ X_4+0{,}0071.\ X_5+0{,}8965.\ X_6+0{,}3209.\ X_7+0{,}8981.\ X_8+0{,}9222.\ X_9+0{,}3960.\ X_{10}+0{,}8907.\ X_{11}$

And the second set variables:

$V_1 = 0{,}7924.\ Y_1+0{,}8666.\ Y_2+0{,}9545.\ Y_3+0{,}5152.\ Y_4$

This pair of canonical variables has a canonical correlation equal to 1.000, indicating a strong correlation between groups of variables.

In an analysis of correlations between the variables considered in the group, you can see which variables are more strongly correlated in these groups. Table 1.2 presents the matrix of correlations among the variables analyzed.

Table 1.1: Correlation between the variables of the groups

Variables	Overturning	Lateral Collision	RearCollision	Lane departure
Animals in thetrack	0.378	0.183	0.147	0.371
Mechanical defect in the vehicle	0.665	0.720	0.721	0.526
Defect in thePathway	0.593	0.843	0.717	-0.008
Disobeyingtrafficsigns	0.849	0.800	0.849	0.314
Sleeping	-0.05	-0.009	-0.135	0.132
Lackofattention	0.872	0.979	0.863	0.181
Ingestionofalcohol	0.569	0.376	0.288	0.332
Do not keep safe distance	0.874	0.939	0.928	0.205
Other	0.888	0.967	0.925	0.226
Overtakingundue	0.614	0.459	0.56	0.088
Speedincompatible	0.843	0.929	0.801	0.317

For each group variable type accidents, identifies a group variable causes of accidents that correlates most strongly.

For *Overturning* the most significant variable in the second group is the variable *Other*, which indicates that the database does not hold in detail the causes of accidents related to the rollover, it is advisable to better define the causes of this type of accident. The results of this study are influenced by human perception at the time of registration. However the variable*Do not keep safe distance*, also obtained a significant value and can be considered strongly correlated to rollover accidents. Mention was also made, however, to a lesser extent, the variable Lack of attention.

While *Lateral Collision* variable correlates strongly to the variable *Lack of attention*, and again the variable*Other* was present, although less significant, suggests caution is also on record of accidents related to lateral collision.

In that covers the variable R*ear collision*, the variable *Do not keep safe distance*was more present, however, again the other variable is highlighted in the background with a strong correlation.

The variable *Lane departure*with less intense, but still correlated variable *Mechanical defect in the vehicle*.

It may be noted that in the analysis, listing the types of the cause of these accidents, there has been a strong presence of variableO*ther*. This result indicates the lack of detail on registration of these accidents, so it is suggested greater caution.

Types of accidents X Phases of the day

The second analysis was performed between the set of variables X Phase types of accidents of the day, reaching the result shown in Table 2.

Table 2: Results of the application of canonical correlation to types of accidents XPhase of the Day

Canonical Variable	R canonical	R2 canonical	Qui-square	GL	p-value
1	0.9968	0.9935	64.6603	16	< 0.0001
2	0.7299	0.5327	11.7109	9	0.2301
3	0.4856	0.2358	3.7224	4	0.4449
4	0.2864	0.0820	0.8989	1	0.3431

As a first analysis, it reached a p-value minimum for the first pair of canonical variables. In canonical correlation (R2) and eigenvalue (R), the observed values give rise to the interpretation that there is a strong correlation group Types of accidents with the variable group Phase of the day.

It is understood, from the first canonical variable first group of variables such as:

$U_1 = 0{,}9304.\ X_{12}+0{,}9482.\ X_{13}+0{,}9856.\ X_{14}+0{,}9971.\ X_{15}$

The second set of variables:

$V_1 = 0{,}9110.\ Y_1+0{,}9771.\ Y_2+0{,}9237.\ Y_3+0{,}2777.\ Y_4$

With a canonical correlation of 0.9935, understands these two sets of variables to be highly correlated. By analyzing the correlation of each variable group tries to get to the variables that most influence this correlation

Table 2.1: Correlation between the variables of the groups

Variables	Overturning	Lateral Collision	RearCollision	Lane Departure
Sunrises	0.820	0.942	0.790	0.178
Nightfall	0.874	0.951	0.832	0.122
Fullnight	0.916	0.967	0.889	0.255
Broaddaylight	0.894	0.976	0.914	0.252

It was identified variables *Overturning* and *Lane Departure*excursion correlated with greater intensity in the variable *Full night*, although again the variable *Lane Departure* still have a correlation with lower intensity compared to the other variables already, and *Lateral Collision* and *Rear Collision* correlate more variable with *Broad daylight*.

Types of accident XMeteorological conditions

The set of variables Types of accidents X Meteorological conditions showed the following results on the canonical correlation analysis:

Table 3: Results application of canonical correlation to Types of accidents X Meteorological Conditions

Canonical Variable	R canonical	R2 canonical	Qui-square	GL	p-value
1	0.998	0.9961	76.2163	28	< 0.0001
2	0.8752	0.7661	26.302	18	0.0931
3	0.7525	0.5663	13.228	10	0.2112
4	0.6854	0.4698	5.7102	4	0.2219

Again the p-value showed a minimum canonical correlation and a high value (0.9961), indicating therefore a strong correlation in the first canonical pair.

The first canonical variable of the first set is defined by:

U1= 0,9906. X16+0,9558. X17+0,8392. X18+0,9415. X19+0,6621. X20+0,9196. X21+0,9347. X22

The second set of variables is determined for:

V1 = 0,8892. Y1+0,9921. Y2+0,8748 Y3+0,2210. Y4

Identified a canonical correlation of 0.9961, it is understood intensive correlation between groups Types of accidents and Meteorological conditions. In table 3.2 is identified correlation matrix between the variables in both groups.

Table 3.1: Correlation between the variables of the groups

Variables	Overturning	Lateral Collision	RearCollision	Lane Departure
Clear Sky	0.910	0.985	0.890	0.197
Rainfall	0.826	0.926	0.906	0.342
Ignored	0.844	0.805	0.927	0.387

Cloudy	0.905	0.929	0.887	0.252
Fog/ Haze	0.405	0.633	0.608	0.218
Sun	0.909	0.925	0.738	0.159
Wind	0.766	0.932	0.816	0.115

It is understood the correlation more sharply variables *Overturning*and*Lateral Collision* with variable Clear Sky. And once again, it found a problem in the database, related to the little details of it, since the variable *Ignored* was larger for correlated variables *Rear Collision* and *Lane Departure*, disregarding the second variable that best correlated to these isRainfall.

Still, it can see the variable *Ignored*with a significant correlation, resuming questioning, above, regarding caution in recording data. If they do not have the required accuracy becomes impractical to use for further study.

Type of accidents X RoadCharacteristics

The final analysis is performed among the groups Types of accidentsXroad characteristics shown in Table 4.

Table 4: Results of the application of canonical correlation to Type of accidents X RoadCharacteristics

Canonical Variable	R canonical	R2 canonical	Qui-square	GL	p-value
1	0.9989	0.9979	98.4276	36	< 0.0001
2	0.9953	0.9907	49.2867	24	0.0017
3	0.8351	0.6974	11.8642	14	0.6172
4	0.5000	0.2500	2.3017	6	0.8900

Like other analyzes the first canonical pair showed a p-value and a minimum eigenvalue (0.9989) and higher canonical correlation (0.9979).

The first canonical variable of the first set is defined by:

$$U1= 0,3199.\ X16+(-0,0504).\ X17+07018.\ X18+(-0,3347).\ X19+0,8171.\ X20+0,9618.\ X21+0,9326.\ X22+0,9268.\ X22+0,5850.\ X22$$

The second set of variables is defined for:

$$V1 = 0,8266.\ Y1+0,8875.\ Y2+0,9331\ Y3+0,5176.\ Y4$$

Finding a canonical correlation of 0.9979 between groups means that the groups are highly correlated. In Table 4.2 shows the correlation between the variables of each group, as well as in other analyzes.

Table 4.1: Correlation between the variables of the groups

Variables	Overturning	Lateral Collision	RearCollision	Lane Departure
Withholes	0.213	0.435	0.201	-0.170
With granular material	-0.169	-0.160	-0.192	0.195
Workontrack	0.759	0.899	0.658	-0.112
MuddyTrack	-0.301	-0.211	-0.314	-0.383

SlipperyTrack	0.643	0.787	0.761	0.259
WetTrack	0.839	0.915	0.920	0.385
OilyTrack	0.742	0.889	0.850	0.330
Dry Track	0.923	0.973	0.905	0.250
Othertypeoftrack	0.562	0.676	0.650	-0.032

The variable Dry *Track* showed strong correlation with the variables *Overturning* and Lateral Collision. To*Lane departure*and *Rear Collision* variable *Wet Track* stood out.

CONCLUSIONS

From the standpoint of understanding the genesis of the accident and the development of mitigation measures, collecting information on the profiles of accidents is an important element in promoting road safety. Since you cannot perform a technical expertise of all accidents, regardless of severity, conventional databases accident are limited to basic information and objective, involving: location, time of the accident, the driver feature, accident characteristics (collision, collision, rollover, rollover, trampling shock with fixed object, other). Besides being made based on the opinion of those records, resulting in a structure of records that do not fully meet the needs of further research, seeking to understand the etiology of accidents.

However, the purpose of the study was met, we were able to correlate the various factors with the most common types of accidents, determining their profile on the BR 365 during the year 2011.

The analysis proved satisfactory, all groups of variables showed a strong correlation, indicating that they are dependent.

According to the results, it can be stated that the rollovers occurred on the highway, had a high correlation with the factor of the driver does not respect the safety distance between vehicles, to be at night, making it difficult for full visibility of the runway; occurred Also when I was with clear skies and the track was dry. However this type of accident should be treated with more caution when registry data, since as noted above the other variable is strongly present in the correlation.

Treating side impact can observe a strong correlation with the lack of attention of the driver, explained by the correlation with the time of day, the sky was clear and dry track. An assumption can be made from this analysis, when a track requires more care when driving, either by the presence of artificial barriers such as speed bumps, or by natural barriers, such as rain and fog, the driver ends up requiring greater attention in direction, which does not occur when it finds conditions such as those mentioned in this result (clear skies, dry runway) that do not require much attention from this, therefore contributed to his lack of attention.

The collision was due back again by reason of non-compliance with the safety distance, besides being the time of day, with rain and wet track. It is relevant to note that both the collision and rollover occurred when traffic had some kind of difficulty, either because it is at night or in the rain. It is assumed, therefore, the sum of the factor of the driver not keep away security ally the difficulty encountered by the driver, either because of rain or the lack of nighttime visibility, contribute to the statistics of accidents on the roads.

The events related to lane departure are explained in their partiality by mechanical defects in the vehicle to be at night, with rain and wet track, although the correlation is not as high. Supposedly, it is concluded that a more circuitous route, plus a few holes on the track in certain stretches are factors of occurrence of the outputs of tracks, making it more dangerous during the rainy season. Guess this confirmed by motorists traveling over the highway, more precisely in the 600-650 km, they still highlight the words as dangerous and biggest complaints are related to deviations flagged or not flagged incorrectly due to duplication of work.

The results presented can be used by those responsible for the highway in an attempt to get a better planning of changes that must be done on the highway and recording their data, with the ultimate goal of reducing the number of accidents. It is suggested that further studies delineate more precisely the association between types of accidents and stretches of highway in which each occurs more frequently in order that the interventions are performed more accurately, in the passages in which they actually occur.

REFERENCES

ASSOCIAÇÃO NACIONAL DE FABRICANTES DE VEÍCULOS AUTOMOTORES.-ANFAVEA. Relatório Anual da Produção Industrial de Veículos Automotores. São Paulo: ANFAVEA, 2011. Disponível em:<http://www.anfavea.com.br> Acesso em: 27 mar. 2012.

AYRES, M; JR, A. M; AYRES, D.L; SANTOS, A.A.S. Bioestat: Aplicações Estatísticas nas áreas das ciências bio-médicas. Pará: 2007, 380 págs.

BOGO, R. L. Análise de correlação canônica e análise de agrupamento Aplicada aos acidentes da BR-116 entre janeiro de 2007 e Novembro de 2009. Dissertação de Mestrado - Universidade Federal do Paraná, 2011.

BRASIL. DEPARTAMENTO NACIONAL DE INFRAESTRUTURA DE TRANSPORTE.Anuário 2010. Disponível em <http://www.dnit.gov.br/rodovias/operacoes-rodoviarias/estatisticas-deacidentes/anuario-2010.pdf>Acesso em: 27 mar. 2012.

COELHO, H.S. Análise da Influência das Características Físico-Operacionais das Vias na Ocorrência de Acidentes de Trânsito nas Rodovias Federais. Brasília: Unb, 1999. Dissertação (Mestrado) Escola deEngenharia, Universidade de Brasília, 1999.

CONFEDERAÇÃO NACIONAL DE TRANSPORTE- CNT/ SEST,SENAT.Pesquisa CNT de rodovias 2011: relatório gerencial. Brasília, 2011. Disponível em:

<http://pesquisarodovias.cnt.org.br/Relatorios/Boletim%20Pesquisa%20CNT%20de%20Rodovias%202011.pdf>. Data de acesso: 28 de março de 2012.

DEPARTAMENTO DE POLÍCIA RODOVIÁRIA FEDERAL -DPRF: Núcleo de Registro de Acidentes e Medicina Rodoviária – NURAM. Acidentesna BR 365 no ano de 2011. Minas Gerais, 13 de março de 2012.

DEPARTAMENTO NACIONAL DE INFRAESTRUTURA DE TRANSPORTES. _DNIT Condições das rodovias: BR-365. Brasília, 2012a. Disponível em: <http://www.dnit.gov.br/rodovias/rodovias-federais/nomeclatura-das-rodovias-federais>. Data de acesso:04 de junho de 2012.

___________ Condições das rodovias: BR-365. Brasília, 2012b. Disponível em: <http://www1.dnit.gov.br/rodovias/condicoes/condicoesdrf.asp?BR=365&Estado=Minas+Gerais&DRF=6>. Data de acesso:04 de junho de 2012.

DEPARTAMENTO NACIONAL DE TRÂNSITO - DENATRAN-. Pesquisa: Impactos Sociais e Econômicos dos Acidentes de Trânsito nas Rodovias Brasileiras. DENATRAN. Brasília, 2006. Disponível em: <http://www.denatran.gov.br Acesso em: 27 mar. 2012.

IPEA.INSTITUTO DE PESQUISA E ESTATÍSTICA APLICADA. Base de Dados do Instituto de Pesquisa Econômica Aplicada do Ministério do Planejamento, Orçamento e Gestão do Brasil. Brasília: Ipeadata,2006. Disponível em <http://www.ipea.gov.br> Acesso em 27 março. 2012.

MÂNICA, ANDRÉ GERALDI. Modelo de previsão de acidentes rodoviários envolvendo motocicletas. Dissertação de Mestrado – Universidade federal do Rio Grande do Sul, 2007.

MEIRELLES, Alexandre Augusto de Castro. Sistema de transportes inteligentes: aplicação da telemática na gestão do trânsito urbano. Dissertação de Mestrado – Programa de Pós-Graduação em Engenharia,2000.

MINAS GERAIS. DEPARTAMENTO DE ESTRADA E RODAGENS. Malha do Estado. Disponível em <http://www.der.mg.gov.br/saiba-sobre/rede-rodoviaria/52-malha-do-estado> Acesso em: 27 março,2012.

MINAS GERAIS. Governo Estadual. Conheça Minas: Rodovias.Minas Gerais, 2012. Disponível em:<http://www.mg.gov.br/governomg/portal/m/governomg/conheca-minas/5662-rodovias/5146/5044>. Data de acesso- 04 de junho de 2012.

OLIVEIRA, MARCOS VNICIUS TEIXEIRA. A natureza dos padrões de variação espaço temporal do volume veicular em ambiente urbano: Estudo de caso em Fortaleza. Dissertação de mestrado – Universidade Federal do Ceará,2004.

ORTUZAR; J, D.; WILUMSEN, L, G. ModelingTransport. England: JonhWiley& Sons, 1996.

PÊGAS,R. S. Diretores do DNIT vistoriam obras nas BR's 050 e 365. 4 de abril de 2012. Uberlândia: Gazeta de Uberlândia. Entrevista concedida a Luciene. Disponível em: <http://gazetaudi.com.br/?p=1229>. Data de acesso: 04 de junho de 2012.

VESSONI, Fabio. Correlação Canônica. São Paulo: MV2 Sistemas de Informação, Outubro,1998.