13. Viva

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13.1. THE PROBLEM

The phenomenon of modern traffic is the product of countless individual decisions, which in turn affect man and the environment, quality of life, and resource usage in many ways.

Equally complex is the effective structure which affects traffic planning. The criteria traffic behaviour, traffic safety efficiency, minimal space usage, compatibility with the surroundings, etc. for all participants must be taken into consideration whereby the priority order of the aspects can of course be set quite differently by each one involved.

The development of traffic planning tools - mostly needed in inner-city areas for minimising the negative effects brought about by motorised traffic - is yet in an early stage. Successful introduction and distribution of innovative technology are dependent on the amount of evaluative data available, whereby the effects on traffic behaviour and traffic safety are the points of most concern.

However, there was until now in the areas of traffic behaviour and traffic safety a lack of suitable measuring methods by which the effects of innovative traffic planning could be adequately analysed within an appropriate time span.

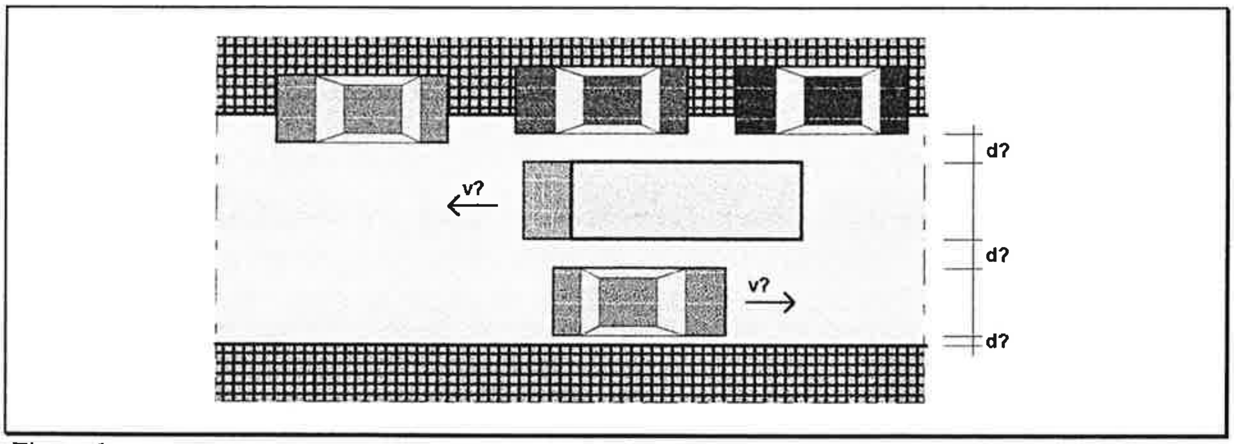


Figure 1:
Dimensions necessary for evaluating the traffic flow and safety of narrow main traffic roads (traffic behaviour - distances apart and speeds - in the case of encounter)

The effects of altered behaviour patterns in traffic, for example as regarding vehicular emissions, have until today had to be demonstrated by means of time-consuming as well as costly methods. It would be conceivable, however, to make use of the exact knowledge of the traffic motions (breaking, acceleration, speed, etc.) in order to calculate the needed data, thereby gaining quite adequate results.

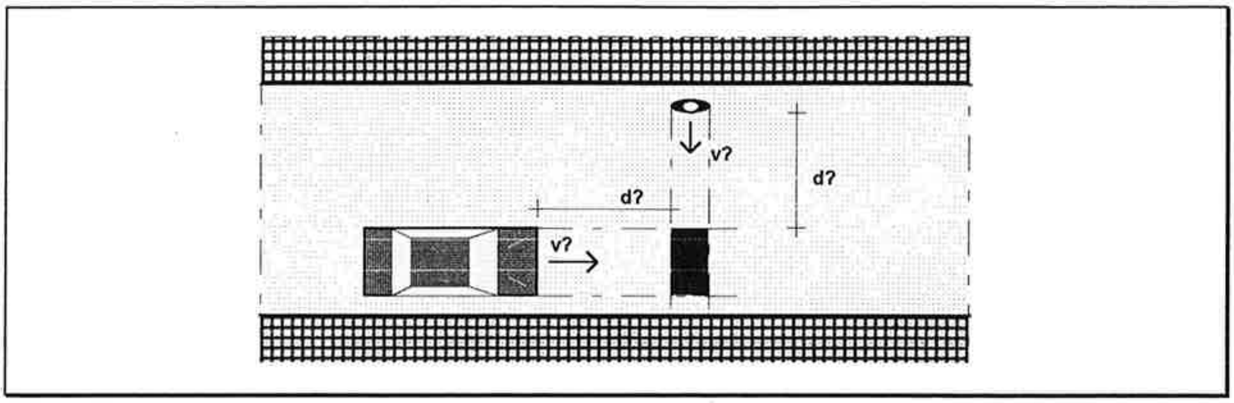


Figure 2:
Values for the evaluation of traffic safety at pedestrian crossings (speeds and directions of and distances between the participants)

In Germany the evaluation of traffic safety relies mostly on accident statistics. However, the quality of these statistics is controversial. Coincidences and unreported accidents, especially for accidents involving traffic participants on foot or bicycle, together with the inherently long periods of time (accidents are, statistically viewed, rare incidents), render this method more or less invalid. Moreover, the prerequisite to an accident statistics is the occurrence of accidents themselves, which is ethically seen as an objectionable practice.

Behaviour changes themselves were until now difficult to quantify. Although with the help of video filming these changes could be estimated, this type of method contained a high degree of subjectivity on the part of the reviewer, and the results were often not accepted by others.

The lack of traffic monitoring instruments is therefore one reason why innovative, space saving road design - which should also lead to more environment-oriented traffic behaviour and/or driving behaviour - is generally accompanied by a long acceptance period.

13.2. NEW TECHNOLOGY OFFERS NEW POSSIBILITIES

With these requirements in mind, the VideoVerkehrsAnalyse-System (Video Traffic Analysis System) ViVAtraffic was created, which makes it possible to measure distances, speeds and accelerations in video pictures, whereby the video film as such has proven to be an optimal and encompassing medium for recording traffic as it occurs.

The recent rapid development in computer hardware, especially as concerns efficiency and expenses as well as the development of image-processing algorithms, now facilitates the usage of computer supported digital image processing at reasonable prices. The traffic analysis system ViVAtraffic incorporates these new developments and emerges as a versatile traffic monitoring instrument. thereby appropriately filling in the above-mentioned gap, as well as supplying a much needed data basis for all areas of traffic planning and research.

13.3. THE SYSTEM VIVATRAFFIC

The system consists of an IBM-compatible PC, a special video card (frame grabber), a separate monitor, and the software. Since potential buyers already possess parts of this configuration, not many additional investments are needed.

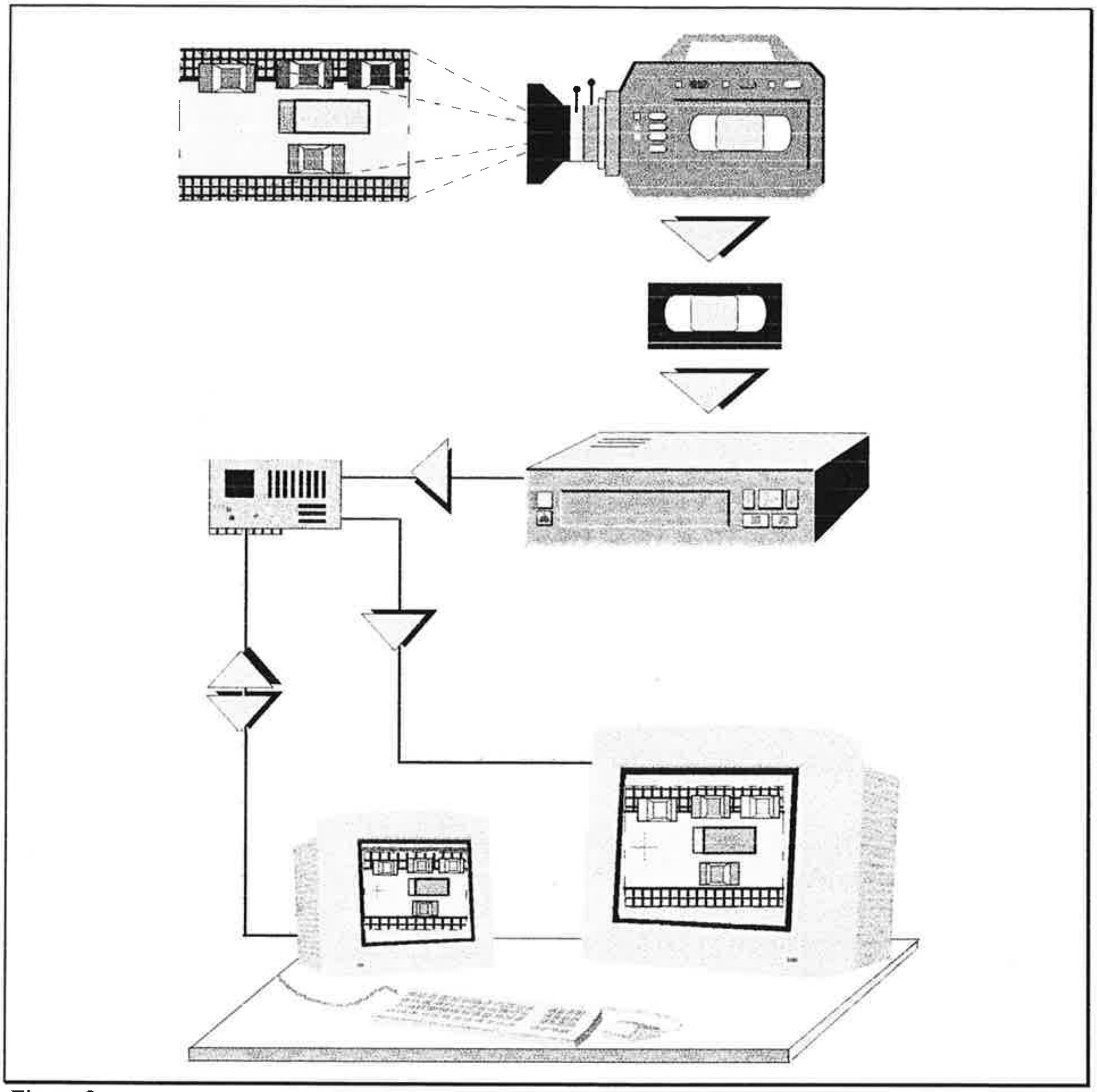
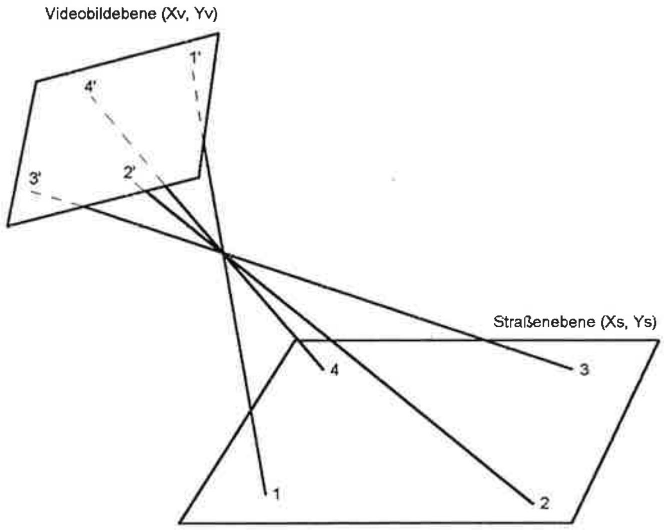


Figure 3:
System components of ViVAtraffic

During the conceptional phase of the system every effort was made toward designing a user-friendly instrument. It is used under the graphic user interface Microsoft Windows 3.xx / 95. No special system knowledge is necessary. The user has extensive on-line assistance at his disposal. Moreover, the system intercepts false applications with respective instructions, thus avoiding loss of data. ViVAtraffic can be installed in German or English.

13.3.1. Basis

The basis of the system is a projective model. By means of this model a point on the street can be related to a respective point on the screen. Thus, all points on the street plane, which can be seen in the video picture, are known.



$$X_s = \frac{C_1X_v+C_2y_v+C_3}{C_4X_v+C_5y_v+1}$$

$$y_s = \frac{C_6X_v+C_7y_v+C_8}{C_4X_v+C_5y_v+1}$$

Figure 4:
Projective model and determination equations for conversion between video picture co-ordinates (x_v, y_v) and street co-ordinates (x_s, y_s)

As a prerequisite for the usage of this model, only four points on the street must be known, and they must be recognizable on the screen. Of these four points, exactly two points must lie on one line. If these points are known, then the corresponding planes are also known (calibrated).

In practice, these points need to be visible for only a brief moment. Already existing videofilms can be subsequently evaluated by ViVAtraffic by measuring given fixed points.

13.4. INTERACTIVE MEASURING WITH VIVATRAFFIC

Following successful calibration, the operator selects those pictures which describe the situation he or she wishes to investigate. By means of the mouse or use of keys then the relevant points are marked. The system converts the marked points on the screen into the real co-ordinates and then calculates the desired data (interactively).

The obtained data can be statistically evaluated with the help of table calculation programs and can be converted into expressive diagrams.

The example shown in Figure 5 was investigated during the research project „The Safety of Narrow Two-way Inner City Main Streets" (Haag/Hupfer, 1992), sponsored by the Federal Ministry of Transport. One significant result of this study, computed with the help of

ViVAtraffic, was the fact that even heavily frequented main streets as narrow as 6.00 meters do not infer any safety deficits. „Altogether there were no relevant differences between the safety of narrow roadways and that of normally wide roadways. Narrow roadways do, however, offer more „shoulder“ space, which in turn can used for streetscaping, thus better integrating main traffic roads to their surroundings. This represents one step toward increased living quality in our cities and away from the dominance of motorised vehicles in main streets.“

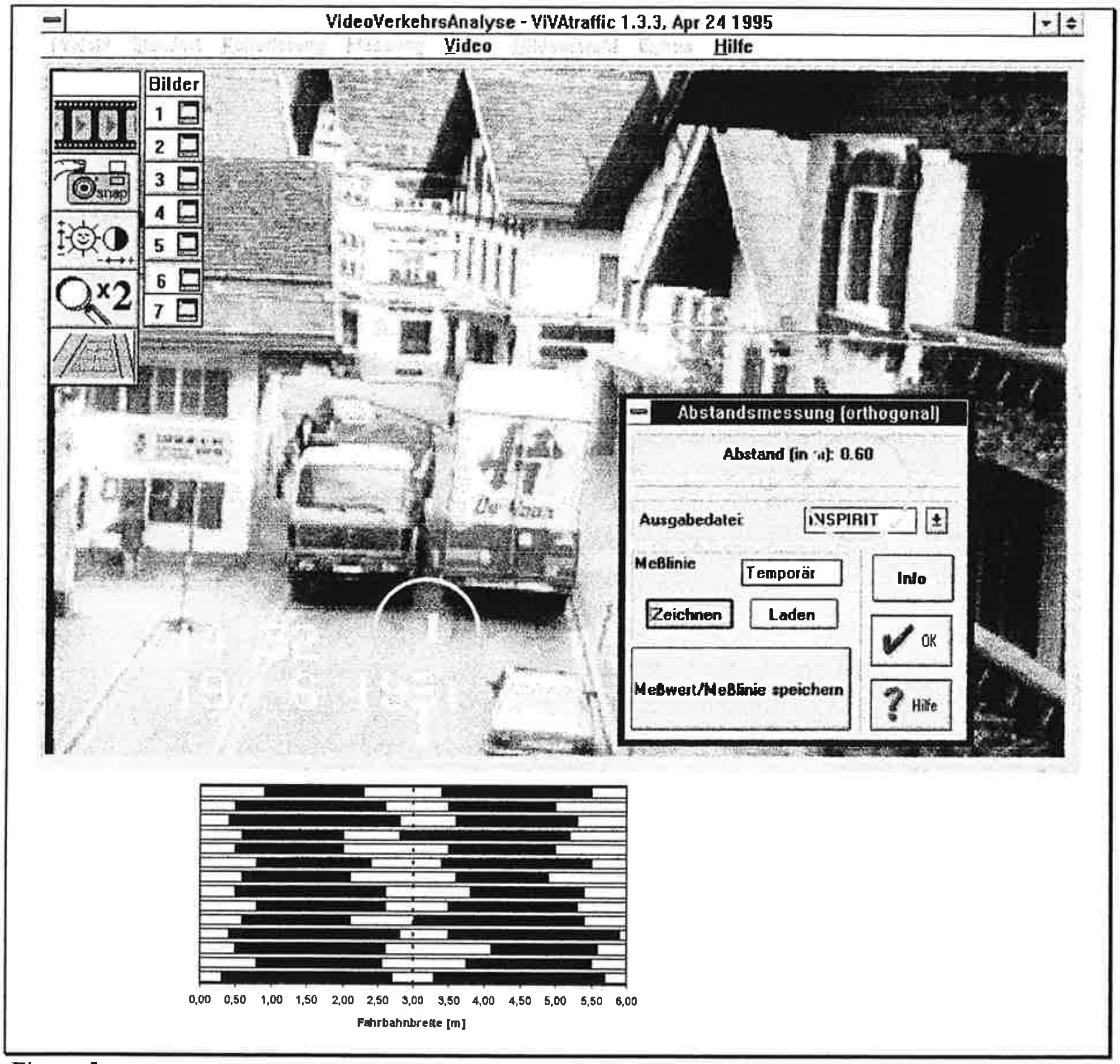


Figure 5:

Right-angle proximity measurement in the case of an encounter between two trucks on the narrow main street of Nesselwang (above) and other various representative examples of encounter in a cross section diagram (black: vehicle, white: distances)

The traffic parameters speed and distance in cases of encounter constituted the basis of these results, whereby the proximity to the roadside borders or to parked automobiles as well as the distances between the passing vehicles were measured. By comparing these values on narrow and normally wide cross sections, the effects of narrow streets could be calculated.

This combination of data was applied in more cases. In particular ViVAtraffic was employed in bicycle traffic, which is hardly possible to monitor with any other existing instruments. In this case, „suggestive lanes"[4] as well as „not genuine one way streets"[5] were evaluated.

Situation oriented measurement of distances and speeds by ViVAtraffic also constituted the basis of the research project „Usage of various types of bus stops on inner city main streets" (Hupfer/Haag, 1994). By means of the System it could be proven, that the bus accessibility and the safety of space saving lane stops („bus piers") are generally better than halting bays.

In addition to evaluating individual measurements at individual cross sections, ViVAtraffic is also able to analyze the general traffic behaviour of a whole area.

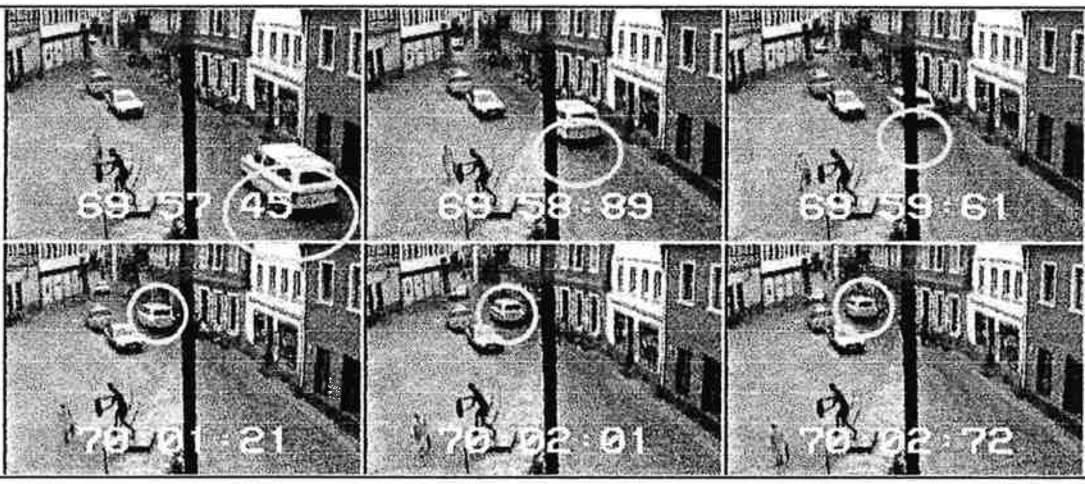


Figure 6:
Sequential cut for evaluation traffic behaviour: speed observation and course of movement

This is done by recording numerous pictures which display the desired situation or movement. Then the traffic participants under examination are marked by means of a mouse piloted cross. Their calculated positions are then stored together as one set of data and can be evaluated by means of any suitable table calculation program.

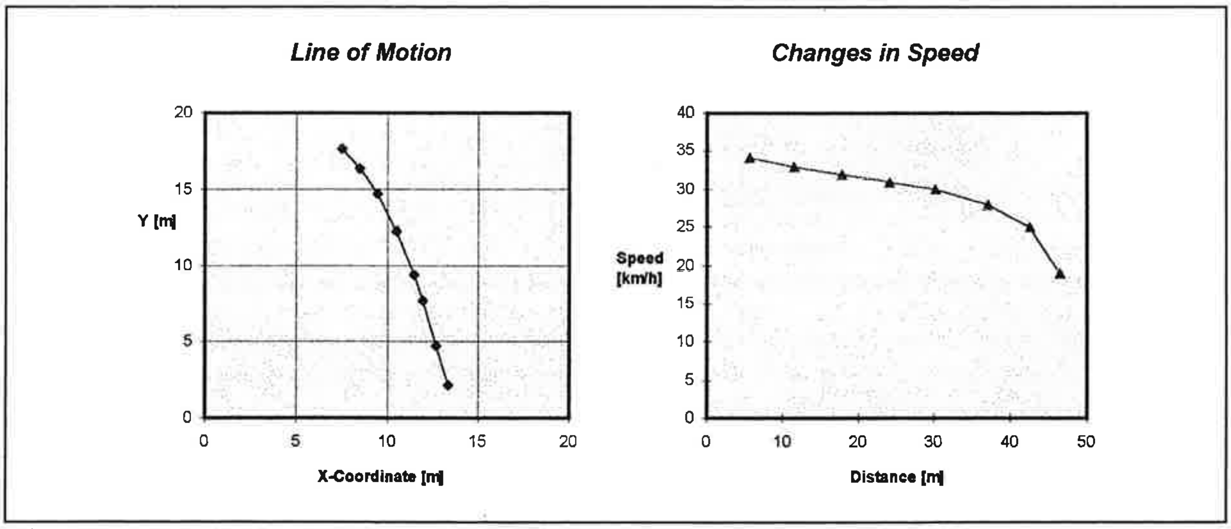


Figure 7: *Representation of the course of a delivery van in the sequence shown in Figure 6: line of motion and changes in speed.*

[4] Suggestive lanes: Coloured lanes alongside a road, suggesting a restricted area for cyclists. They are not legally binding, but do however cause motorists to move more toward the centre of the street, thus causing them to reduce their speed.

[5] Not genuine one way streets: For motorised vehicles only one driving direction, for cyclists both directions allowed.

Thus, not only is it possible to collect data at certain locations, but additionally a complete survey of following traffic can be made and analyzed. Examples of application areas are: Traffic behaviour of motorists in approaching pedestrian crossings, crossing behaviour of pedestrians, effects of signalling speed reduction, acceleration behaviour. etc. From this data it is also possible to calculate the negative influence on the environment (pollution, noise, etc.)

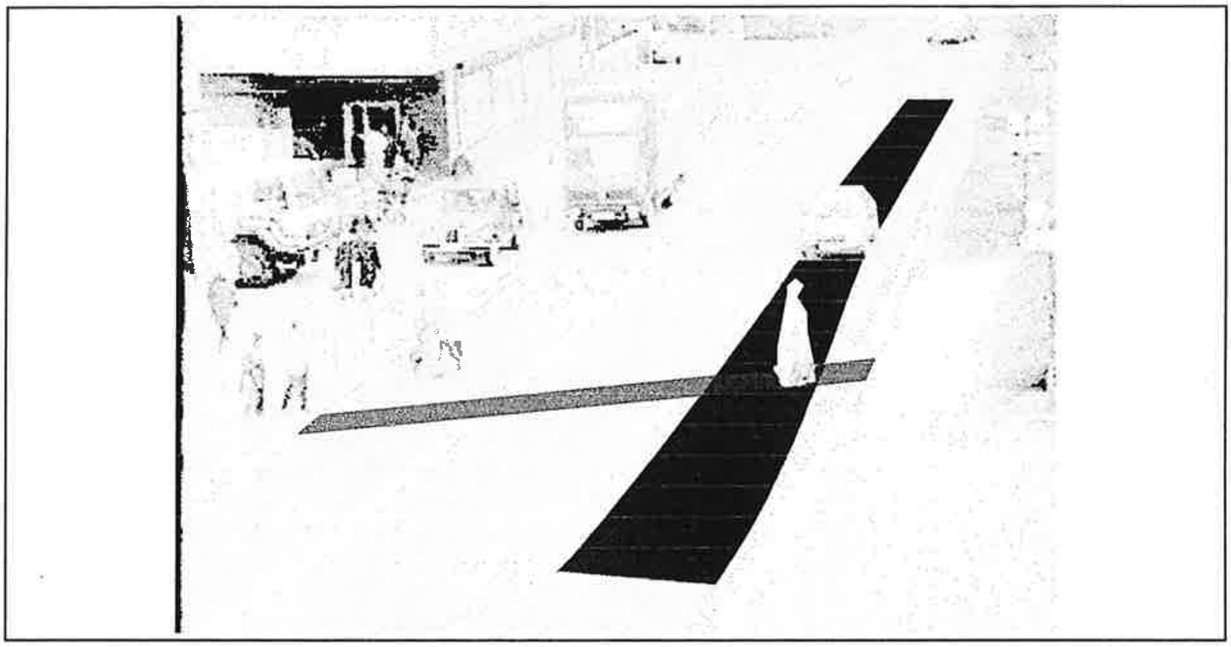


Figure 8:
Conflict situation vehicle/pedestrian. Vehicle speed 35 km/h; pedestrian speed 2.5 m/s. The pedestrian accelerate while crossing. The vehicle decelerates from 55 km/h to 35 km/h. Minimal time interval during the conflict situation until collision is 1.3 s.

At present, research work sponsored by the „Stiftung Rheinland-Pfalz für Innovation“ is being done on modifying traffic conflict technique especially for pedestrian crossings.

In the early 1980's, the first efforts in establishing a traffic conflict technique as a supplement to accident quotas resulted in failure mainly due to the method's lack of objectiveness. The modified traffic conflict technique based on ViVAtraffic will make an objective evaluation of traffic safety in traffic situations possible, on the bases of video recordings. Traffic parameters can be thereby determined objectively and exactly and used toward forming an evaluative basis.

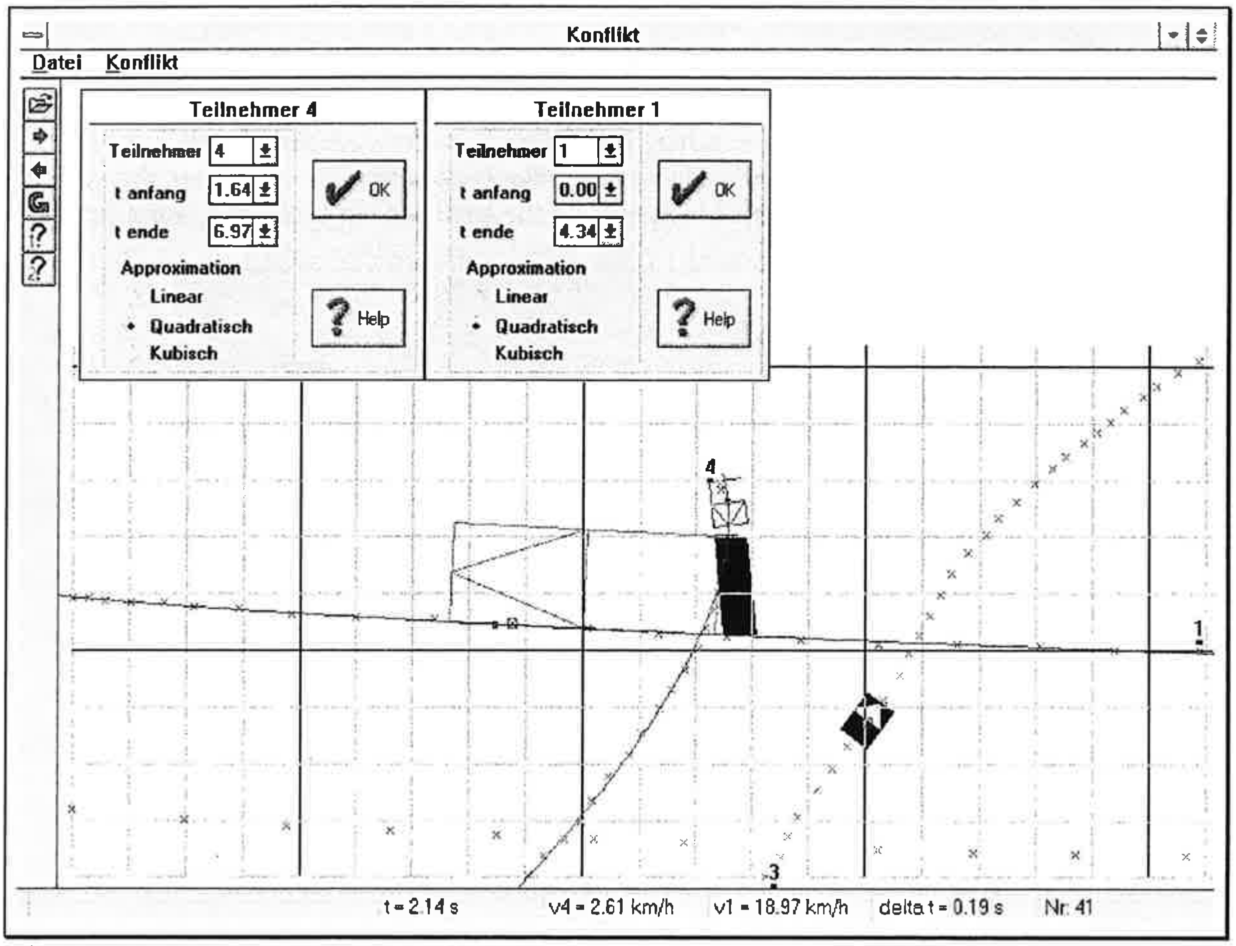


Figure 9:
Evaluation of a conflict between a vehicle (#1) and a pedestrian (#4). The measured movements are approximated in course and speed. The rhombus-shaped, black area represents the resulting potential area of conflict if the participants do not change their momentary direction. Out of the momentary speed of each participant, the time interval can be calculated, by which the two participants „miss" each other (here: 0.19 s). In the case of simultaneous presence of both traffic participants in the conflict area, the Time To Collision (TTC) can be determined.

By means of the interactive possibilities of the system, the most various parameters of any given traffic situation, be they situation oriented or location oriented, can be determined. The effectiveness of traffic planning measures as regarding traffic safety, relevance to the surroundings as well as to the environment, etc. can thus be examined and optimized.

13.5. AUTOMATIC TRAFFIC-MONITORING

The previously discussed possibilities of the ViVAtraffic system require the ability of the operator to recognize a situation and to accordingly select the pictures which contain the situation. Automatic recognition and evaluation would require a type of hardware which would greatly multiply the costs of the whole system. Moreover, at present no satisfactorily dependable algorithms are known which can recognize and evaluate specific situations in a reasonable period of time.

Automatic recognition of a certain situation is not necessary for the determination of standard traffic data. In this case all motorized vehicles should be counted and distinguished according to their type and their speed should be determined. For the determination of this standard data, which is essential to almost every kind of traffic planning, an automatic tool was added to ViVAtraffic.

Basically, the automatic image processing is derived from the forming of differences between two pictures. A gray value is assigned to each point in a picture. By subtracting the pictures, unchanged spots have a sum of 0, spots with changes (=movement) have a value larger than 0. For the evaluation of a whole picture, 262,144 picture points must be compared within two pictures. This kind of performance is beyond the possibilities of a low-cost system, given the required real time.

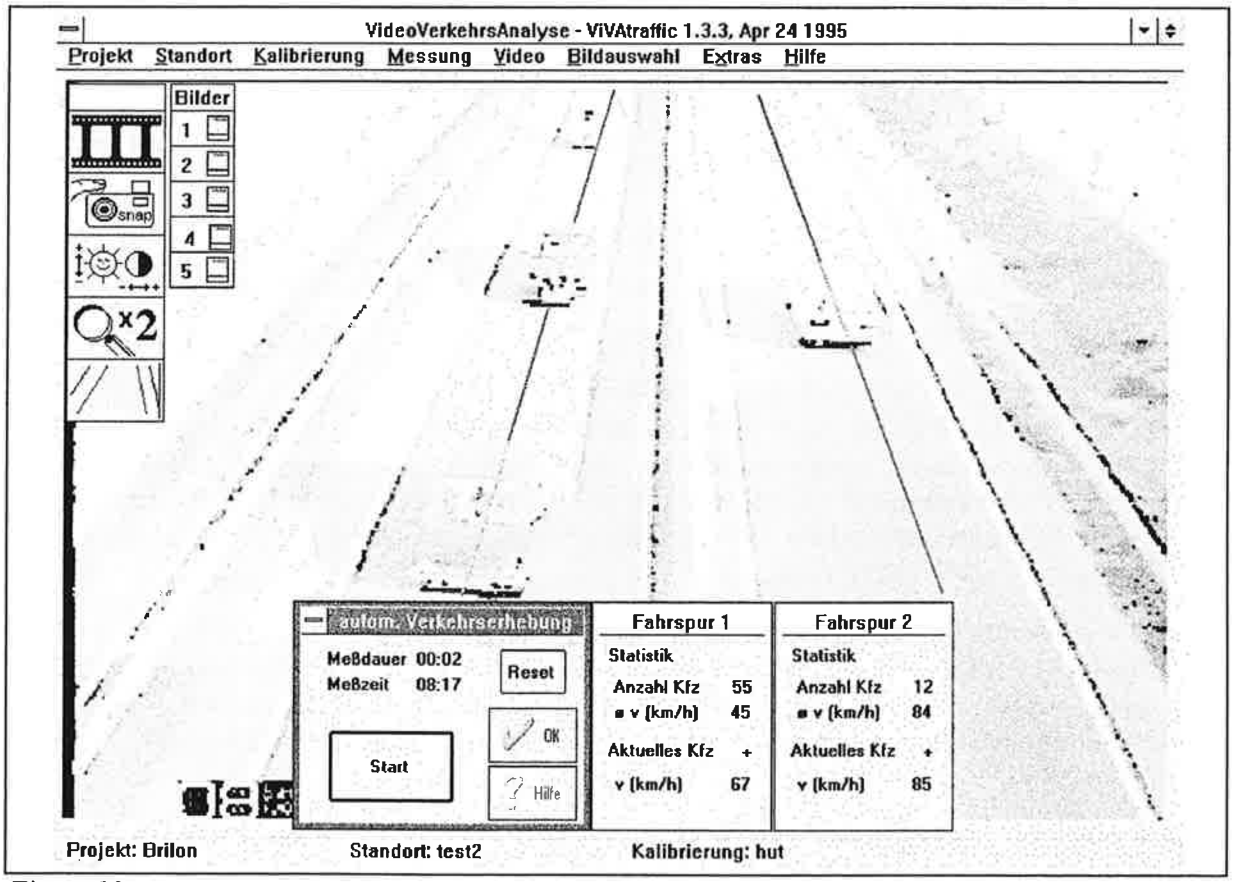


Figure 10:
Automatic traffic monitoring with ViVAtraffic at the end of a state highway. Left lane (oncoming traffic): reduced speed caused by congestion; right lane: higher speed and acceleration at the beginning of the highway. (dark gray: measuring line; light gray: detected vehicle; dark gray, horizontal: determined edge of the vehicle for speed measurement)

The picture evaluation in ViVAtraffic is therefore restricted to a number of lines. The operator must secure two points as basis of a line, on which the system carries out the automatic analysis of the pictures. This line must lie on the road in such a position, so as to be „overrun" by most of the vehicles. This way the system recognizes the vehicles, measures their lengths[6]

[6] Hereby meaning the length of the vehicle in the picture which later is used for classifying the vehicles in the evaluation.

and speeds as well as the time gaps[7] between the vehicles, and then saves the data and the measured times.

Afterward, evaluative tables can be automatically produced with the assistance of a table calculation program. In this manner, the data can be collected as individual values with the most possible precision and can be subsequently combined as desired. A follow-up measurement at any later time is of course also possible. If initially only the amount of traffic and speeds were measure, then the video material could, for example, also supply the time intervals. Moreover, specific situations could be interactively analyzed.

The System ViVAtraffic is a video traffic analysis system which besides having the functions of conventional monitoring systems, additionally has the ability to analyze behaviour patterns in traffic. Thus it is possible for the first time ever to test the effectiveness of traffic planning measures. With this system, the effects on traffic safety and traffic behaviour of all traffic participants can be determined and evaluated so that traffic planning can be carried out accordingly.

13.6. REALIZATION

The development of ViVAtraffic began in 1986. The first version, developed for research projects, was named DiVA (Digitale VekehrsAnalyse = Digital Traffic Analysis). The second generation, with expanded functionality and the ability of automatic traffic survey, was named ViVA (VideoVerkehrsAnalyse = video traffic analysis). The name ViVAtraffic stands for the system now being introduced to the market. Each of these development stages represents a significant improvement of the system.

ViVA was presented in 1993 at the Hannover Messe Industrie (Industrial Fair at Hannover) and at the CeBIT (the world biggest computer fair in Hannover) in 1994. The developers of the system got a prize for outstanding scientific achievements, given by the Federation of German Automobile Industry (VDA - Verband der Deutschen Automobilindustrie e.V.).

13.7. THE VIVATRAFFIC-TEAM

ViVAtraffic was - and is still being - developed by an interdisciplinary team of computer specialists and traffic engineers from the Transportation Department of the University Kaiserslautern under the direction of Professor Hartmut H. Topp.

The theoretical foundations were laid by Karl-Heinz Schweig and Thilo Horstmann. They researched photogrammetrical relationships and made the first measurements of physical data from the video films with the PC. The results were published in the „Research Report on the Usage of the Model Principle 'Soft Separation' on Inner City Main Streets.“

[7] The time gaps between vehicles. The measured time gaps are directly related to and provide information on traffic flow and traffic quality.

The modification of the system as well as the implementation of further analysis possibilities were accomplished under the direction of Christoph Hupfer, who improved and expanded the functions of ViVAtraffic, which in turn played an essential role as his monitoring instrument in two further research projects.

The transfer of the „Spaghetti Code" into a sellable product under Microsoft Windows was performed by Thilo Horstmann. The theoretical foundations of the automatic traffic monitor were laid by Bernd Pollak, and the further development of these components was carried out by Markus Ebbecke.

At present ViVAtraffic is being supervised and modified by Volker Rudolph as well as Markus Ebbecke and Christoph Hupfer. All members of the ViVAtraffic Team are or were employees of the Transportation Department at the University Kaiserslautern.

13.5. APPLICATION

ViVAtraffic was developed for the purpose of testing the abilities of the various traffic planning and traffic regulation instruments. The system can be used for situation and infrastructure analysis, safety inspection, as well as the determination of basic data in traffic affairs.

The main publication domain is therefore the research of basic data in universities. The system is being used for most of their projects by the Universities of Hannover, Kassel, Dresden, Darmstadt and Kaiserslautern.

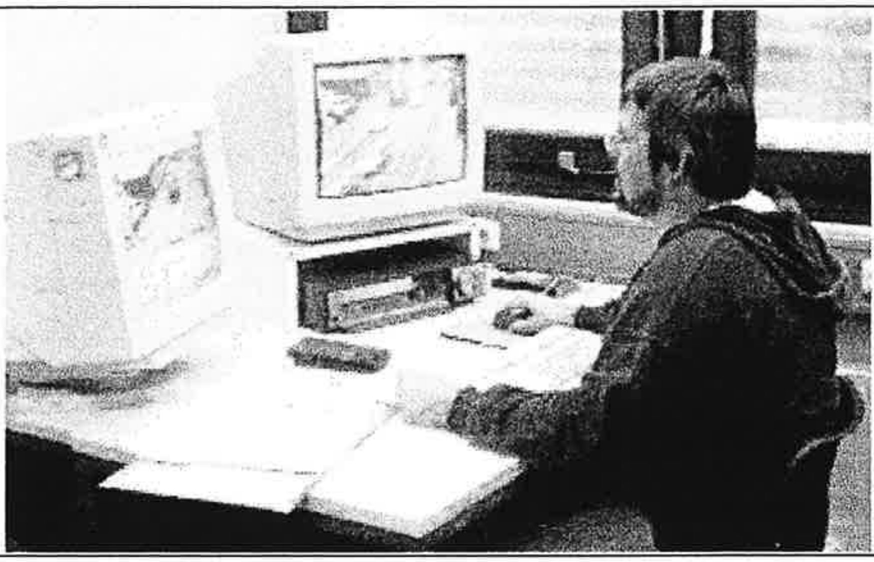


Figure 11:
ViVAtraffic working place with IBM-compatible PC with video card, 2 monitors and video recorder.

However, ViVAtraffic is, also an efficient system for use by planning offices and community planners as well as decision makers, who increasingly need more detailed and more complex traffic data in their situations related planning process. Users will welcome the fact, that no special preparations or skills are necessary in operating the system. The utilized components are inexpensive thanks to their mass production. The collected data can be graphically arranged. Furthermore, all situations can be documented in video pictures or picture sequences.

Up to now, there has been no intensive advertising about the system. Nevertheless, fact ViVAtraffic is already being used in various universities and planning offices. The distribution and the care of the system are managed by the GVA Gesellschaft für VerkehrsAnalyse mbH (Society for Traffic Analysis Limited) in Kaiserslautern which was founded for this purpose.

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