Študijný program / *Study programme:*
Geometria a topológia / *Geometry and Topology*

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Študijný program / *Study programme:*
Geometria a topológia / *Geometry and Topology*

Názov / *Title*
Dátovo závislé, topológiu zachovávajúce zjednodušovanie pletív
Data-dependent, Topology-preserving Mesh Simplification

Jazyk záverečnej práce / *Language of Thesis*
anglický / *English*

Školiteľ / *Tutor*
doc. RNDr. Andrej Ferko, PhD.

Anotácia / *Annotation*
Skúmame dátovo závislé, topológiu zachovávajúce zjednodušovanie trojuholníkových sietí, ktoré skombinuje viaceré zdroje riadiacich dát pre rozsiahlu databázu predvypočítaných inštancií daného objektu s premenlivou úrovňou detailu. Primárnym cieľom je zobrazovanie v reálnom čase, sekundárnym kompresia dát.
We study the data-dependent, topology-preserving mesh simplification which aims to combine multiple sources of control data for a bigger database of object instances with varying precision of surface detail.

Cieľ / *Aim*
Hlavným cieľom bude nájsť čo najvhodnejší spôsob modelovania objektov scény na zobrazovanie v reálnom čase vo viacerých úrovniach detailu. Tieto sa budú generovať dátovo závislými sieťami trojuholníkov, kde riadiace dáta budú pochádzať z viacerých zdrojov, napr. zo senzorov, najlepších pohľadov, vizuálnych obalov. Zjednodušovanie bude mať globálnu a lokálnu fázu. Lokálna fáza zohľadní aj hĺbku ostrosti a niektoré ďalšie nastavenia danej zdrojovej i cieľovej scény. Sekundárnym cieľom bude preskúmanie kompresného potenciálu novej reprezentácie daného objektu.
The primary goal is to find the most appropriate way of modeling scene objects for real-time display at multiple levels of detail. This will be generated by data-dependent triangulations, where the control data will come from several sources, for example, the sensors, the best views, visual hulls. The simplification process will consist from global and local phase. The local phase will take into account the depth of field and some other parameters of the source and target scenes. A secondary objective will be to evaluate the compression potential of a new representation of the scene object.

Literatúra / *Literature*
ČERVEŇANSKÝ, M et al. 2010. Parallel GPU-based data-dependent triangulations. pp. in Computers & Graphics, vol 34, no 2 (2010) 125-135. NOCIAR, M – FERKO, A. 2010. Feature-preserving mesh denoising via attenuated bilateral normal filtering and quadrics. pp. 149-156 in SCCG 2010. [online] http://dl.acm.org/citation.cfm?id=1925086 EDELSBRUNNER, H – HARER, J. 2010. Computational Topology. An Introduction. Amer. Math. Soc., Providence, RI. EDELSBRUNNER, H . 2001. Geometry and Topology for Mesh Generation. Cambridge Univ. Press, Cambridge, UK. DEY, T. K. et al. Topology preserving edge contraction. Publ. Inst. Math. Beograd. 66 (1999), 23-45. LAURENTINI, A. 1994. The visual hull concept for silhouette-based image understanding. IEEE Trans. Pattern Analysis and Machine Intelligence. Vol 16 no 2 (1994), 150-162.
ČERVEŇANSKÝ, M et al. 2010. Parallel GPU-based data-dependent triangulations. pp. in Computers & Graphics, vol 34, no 2 (2010) 125-135. NOCIAR, M – FERKO, A. 2010. Feature-preserving mesh denoising via attenuated bilateral normal filtering and quadrics. pp. 149-156

in SCCG 2010. [online] http://dl.acm.org/citation.cfm?id=1925086 EDELSBRUNNER, H – HARER, J. 2010. Computational Topology. An Introduction. Amer. Math. Soc., Providence, RI. EDELSBRUNNER, H . 2001. Geometry and Topology for Mesh Generation. Cambridge Univ. Press, Cambridge, UK. DEY, T. K. et al. Topology preserving edge contraction. Publ. Inst. Math. Beograd. 66 (1999), 23-45. LAURENTINI, A. 1994. The visual hull concept for silhouette-based image understanding. IEEE Trans. Pattern Analysis and Machine Intelligence. Vol 16 no 2 (1994), 150-162.

Poznámka / *Comment*

Výsledná metóda bude publikovateľná v časopise CAGD a pod.
The new method of boundary representation (and maybe compression) will be published in CAGD journal or in a similar one.

Kľúčové slová / *Keywords*

computational topology, mesh processing
computational topology, mesh processing

Študijný program / *Study programme:*
Geometria a topológia / *Geometry and Topology*

Názov / *Title*
Metódy neštandardnej analýzy v harmonickej analýze
Methods of nonstandard analysis in harmonic analysis

Jazyk záverečnej práce / *Language of Thesis*
anglický / *English*

Školiteľ / *Tutor*
prof. RNDr. Pavol Zlatoš, PhD.

Anotácia / *Annotation*
Neštandardná analýza umožňuje zahrnúť intuitívne názorné metódy založené na systematickom využití nekoenečne malých do rôznych oblastí matematiky. Predpokladá sa, že uchádzač bude pracovať na ich aplikáciách v harmonickej analýze.
Nonstandard analysis enables to incorporate some intitively transparent methods based on the systematic use of infinitesimals into variuos branches of mathematics. The applicant is supposed to work on their applications in harmonic analysis.

Cieľ / *Aim*
Naučiť sa a zvládnuť metódy neštandardnej analýzy a použiť ich pri hyperkonečných aproximáciách Fourierovej transformácie na všeobecných lokálne kompaktných abelovských grupách.
To learn and master the methods of nonstandard analysis and apply them in hyperfinite approximations of the Forier transform on general locally compact abelian groups.

Literatúra / *Literature*
R. Goldblatt, Lectures on the hyperreals, Springer, New York,etc., 1998. E.I. Gordon, Nonstandard methods in commutative harmonic analysis, Amer. Math. Soc., Providence, R.I., 1997. E. Hewitt, K.A. Ross, Abstract harmonic analysis I, II, Springer, Berlin, etc., 1963, 1970. P. Zlatoš, Gordon's conjectures: Pontryagin-van Kampen duality and Fourier transform in hyperfinite ambience, arXiv:1409.6128v2[math.CA].
R. Goldblatt, Lectures on the hyperreals, Springer, New York,etc., 1998. E.I. Gordon, Nonstandard methods in commutative harmonic analysis, Amer. Math. Soc., Providence, R.I., 1997. E. Hewitt, K.A. Ross, Abstract harmonic analysis I, II, Springer, Berlin, etc., 1963, 1970. P. Zlatoš, Gordon's conjectures: Pontryagin-van Kampen duality and Fourier transform in hyperfinite ambience, arXiv:1409.6128v2[math.CA].

Poznámka / *Comment*
Výsledky budú publikované v časopisoch pokrytých Mathematical Reviews.
Results will be published in journals covered by Mathematical Reviews.

Kľúčové slová / *Keywords*
Neštandardná analýza, Fourierova transformácia, aproximácia
Nonstandard analysis, Fourier transform, approximation

Študijný program / *Study programme:*
Geometria a topológia / *Geometry and Topology*

Názov / *Title*
Metódy neštandardnej analýzy v topologických grupách
Methods of nonstandard analysis in topological groups

Jazyk záverečnej práce / *Language of Thesis*
anglický / *English*

Školiteľ / *Tutor*
prof. RNDr. Pavol Zlatoš, PhD.

Anotácia / *Annotation*
Neštandardná analýza umožňuje zahrnúť niektoré intuitívne názorné metódy založené na systematickom používaní nekonečne malých do viacerých matematických disciplín. Predpokladá sa, že uchádzač bude pracovať na ich aplikácií v topologických grupách.
Nonstandard analysis enables to incorporate some intuitively transparent methods based on the systematic use of infinitesimals into variuos branches of mathematics. The appliccant is supposed to work on their applications in topological groups.

Cieľ / *Aim*
Naučiť sa a zvládnuť metódy neštandardnej analýzy a použiť ich pri hyperkonečných aproximáciách lokálne kompaktných abelovských grúp.
To learn and master the methods of nonstandard analysis and apply them in hyperfinite approximations of locally compact abelian groups.

Literatúra / *Literature*
R. Goldblatt, Lectures on the hyperreals, Springer, New York,etc., 1998. E.I. Gordon, Nonstandard methods in commutative harmonic analysis, Amer. Math. Soc., Providence, R.I., 1997. L.S. Pontryagin, Topological groups, Gordon & Breach, New York, 1986. P. Zlatoš, Gordon's conjectures: Pontryagin-van Kampen duality and Fourier transform in hyperfinite ambience, arXiv:1409.6128v2[math.CA]
R. Goldblatt, Lectures on the hyperreals, Springer, New York,etc., 1998. E.I. Gordon, Nonstandard methods in commutative harmonic analysis, Amer. Math. Soc., Providence, R.I., 1997. L.S. Pontryagin, Topological groups, Gordon & Breach, New York, 1986. P. Zlatoš, Gordon's conjectures: Pontryagin-van Kampen duality and Fourier transform in hyperfinite ambience, arXiv:1409.6128v2[math.CA]

Poznámka / *Comment*
Výsledky budú publikované v časopisoch pokrytých Mathematical Reviews.
Results will be published in journals covered by Mathematical Reviews.

Kľúčové slová / *Keywords*
Neštandardná analýza, topologická grupa, aproximácia
Nonstandard analysis, topological group, approximation

Študijný program / *Study programme:*
Geometria a topológia / *Geometry and Topology*

Názov / *Title*
Podgrafy multikriteriálnych triangulácií
Subgraphs of Multicriteria-optimized Triangulations

Jazyk záverečnej práce / *Language of Thesis*
anglický / *English*

Školiteľ / *Tutor*
doc. RNDr. Andrej Ferko, PhD.

Anotácia / *Annotation*
Skúmame nové rozšírenia a zovšeobecnenia podgrafov Delaunayovej triangulácie v rovine pre triangulácie s jedným alebo viacerými špeciálnymi kritériami. Výsledky by mali viesť k novým alebo rýchlejším algoritmom konštrukcie.
We study novel extensions and generalizations of subgraphs of Delaunay triangulation to specialized or multicriteria planar triangulations. The results will provide new or faster construction algorithms.

Cieľ / *Aim*
Vlastnosti aplikačne užitočných podgrafov štandardnej rovinnej Delaunayovej triagulácie (DT) sú pomerne dobre známe, čo neplatí o analogických podgrafoch špecializovaných triangulácií a ich zovšeobecnení do multikriteriálnych triangulácií. Viaceré z hrán podgrafov DT možno charakterizovať priamo, deklaratívne (napr. kritériami prázdnych oblastí) alebo procedurálne (napr. Urquhart graph, minimálna kostra). Cieľom práce je rozšíriť teóriu, študovať vlastnosti i vzťahy podgrafov a analyzovať výpočtovú zložitosť. Porozumenie deklaratívnej charakteristike hrán podgrafov by mohlo priniesť rýchlejšie algoritmy konštrukcie špeciálnych triangulácií alebo ich aproximácií.
The properties of subgraphs of Delaunay triangulation are well-studied, which is not the case of subgraphs of specialized triangulations and their generalization, multicriteria-optimized triangulations. Some of their edges can be characterized directly (e.g. using empty-region graphs) or procedurally (e.g. Urquhart graph, minimum spanning tree). Thesis goal is to build the theory of procedural or declarative properties and relationships to analyze the computational complexity. Understanding of directly characterizable subgraphs would possibly lead to faster algorithms for special triangulations or their approximations.

Literatúra / *Literature*
Kolingerová, I - Ferko, A . 2001. Multicriteria-optimized triangulations. The Visual Computer 17 (6), 380-395. Krüger, B. 2016. Simulating Triangulations: Graphs, Manifolds and (Quantum) Spacetime. Erlangen: FAU University Press. Aurenhammer F et al. 2013. Voronoi Diagrams and Delaunay Triangulations. World Scientific Publishing Company. Edelsbrunner, H. 2011. Alpha shapes --- a survey. In Tessellations in the Sciences... http://pub.ist.ac.at/~edels/Papers/2011-B-03-AlphaShapes.pdf
Kolingerová, I - Ferko, A . 2001. Multicriteria-optimized triangulations. The Visual Computer 17 (6), 380-395. Krüger, B. 2016. Simulating Triangulations: Graphs, Manifolds and (Quantum) Spacetime. Erlangen: FAU University Press. Aurenhammer F et al. 2013. Voronoi Diagrams and Delaunay Triangulations. World Scientific Publishing Company. Edelsbrunner, H. 2011. Alpha shapes --- a survey. In Tessellations in the Sciences... http://pub.ist.ac.at/~edels/Papers/2011-B-03-AlphaShapes.pdf

Poznámka / *Comment*

Výsledky budú publikovateľné v časopise ako CAGD.
The new methods and findings will be published in CAGD journal or in a similar one.

Kľúčové slová / *Keywords*
computational complexity, planar triangulations
computational complexity, planar triangulations

Študijný program / *Study programme:*
Geometria a topológia / *Geometry and Topology*

Názov / *Title*
Simulácia veľkých rozmerov dynamiky viacerých kvapalín s pohyblivými prekážkami.
Large Scale Simulations for Multiple Fluid Dynamics With Moving Interfaces

Jazyk záverečnej práce / *Language of Thesis*
anglický / *English*

Školiteľ / *Tutor*
prof. RNDr. Roman Ďurikovič, PhD.

Anotácia / *Annotation*
Coupling 2D and 3D Simulation in a Lagrangian Way A 2D simulation based on the SWE is often used to simulate large bodies of water. Although a real-time simulation can be achieved \cite{Hagen05} various limitations result from the 2D nature of the simulation. Because a height field is used to represent the fluid no complex effects, like drops, splashes or breaking waves, might be simulated. One simply solution is to add uncoupled particles to the simulation like in \cite{Chentanez10}, where sprays, foam, and waterfalls were simulated by generating uncoupled particles and interaction between these particles and the height filed was handled. Simulation of breaking waves was achieved by adding fluid sheets in \cite{Thurey07}. A full coupling of 2D and 3D simulation was presented in \cite{Thurey06} using lattice Boltzmann method. Even better results were achieved in \cite{Chentanez11}, where the approach from \cite{Irving06} was enhanced. A combination of tall cells and 3d grid cells was employed to simulate water in real-time. Although good results were achieved using the previously mentioned methods all handle the fluid in Eulerian way. We would like to couple SPH-based shallow water simulation with a full 3D SPH simulation. The use of SPH for both the 2D and the 3D simulation gives a fully Lagrangian approach. The 3D simulation will be used only near the fluid surface where the complex effect with high visual impact occur. Therefore the most of the fluid domain will be simulated with a fast 2D approach and a fast simulation should be achieved. Erosion Process and Fluid Mixing in 2D SPH We would like to add advection of concentrations between particles to SPH-based shallow water simulation. A 2D representation of the fluid can not fully capture the diffusion and sedimentation processes in the fluid. Therefore we will create new particles by dividing every fluid particle to multiple particles in the vertical direction. These particles will move together in the fluid simulation and will be taken in the computation as a single particle. In the mixing process, where concentrations will be advected, the created particles will be handled as separate particles and carry the dissolved material. The proposed approach to fluid mixing can be exploited in the erosion process as well as in mixing of several fluids. Because several subsamples of dissolved material are stored for every simulation particle a volumetric raytracing can be performed. A realistic visualization of the erosion precess can be acquired in this way. Multiresolution Simulation A multiresolution simulation is usually used to enhance the efficiency of the simulation. In \cite{Adams07} a 3 to 8-times speedup was achieved. Several concepts of particle merging and splitting were used in the resampling process. From two \cite{Adams07} to several particles \cite{Desbrun99} were merged and split. Virtual particles were used in \cite{Keiser06}. Different criterion for particle merging and splitting were used as well. The speed of the deformation was used in \cite{Desbrun99} and the geometrical complexity was used in \cite{Adams07}. A different approach was proposed in \cite{Cohen10}. A translating Eulerian grid was used to to concentrate the computation into important regions and the rest was simulated by particles. This concept can be taken as a level of detail approach as well as the solution from \cite{Solenthaler11}, where a high resolution simulation was used to capture the regions of interest. We would like to employ

the multiresolution simulation to concentrate the computation into region of visual importance. A higher-resolution simulation will be used in this regions. Such regions are the regions where an interaction between fluid and solid occurs. Another criterion will be view dependent criterion based on the field of view of the camera and the distance from the camera. It is difficult to say which resampling solution will perform best for a 2D particle-based simulation. Because of that we will try several solutions and employ the one with best trade-off between speed and stability. Enhancing Sampling of the Fluid A low sampling of the fluid can result in visual artifacts. To resolve this problem in \cite{Ando11} particles were added in the thin fluid regions to prevent rupturing of this regions. A particle was added among two candidate particles and the physical properties were redistributed between the created and candidate particles. This method is employed for the PIC/FLIP method and no such resampling is needed for the 3D SPH because such problem do not occur here.

Coupling 2D and 3D Simulation in a Lagrangian Way A 2D simulation based on the SWE is often used to simulate large bodies of water. Although a real-time simulation can be achieved \cite{Hagen05} various limitations result from the 2D nature of the simulation. Because a height field is used to represent the fluid no complex effects, like drops, splashes or breaking waves, might be simulated. One simply solution is to add uncoupled particles to the simulation like in \cite{Chentanez10}, where sprays, foam, and waterfalls were simulated by generating uncoupled particles and interaction between these particles and the height filed was handled. Simulation of breaking waves was achieved by adding fluid sheets in \cite{Thurey07}. A full coupling of 2D and 3D simulation was presented in \cite{Thurey06} using lattice Boltzmann method. Even better results were achieved in \cite{Chentanez11}, where the approach from \cite{Irving06} was enhanced. A combination of tall cells and 3d grid cells was employed to simulate water in real-time. Although good results were achieved using the previously mentioned methods all handle the fluid in Eulerian way. We would like to couple SPH-based shallow water simulation with a full 3D SPH simulation. The use of SPH for both the 2D and the 3D simulation gives a fully Lagrangian approach. The 3D simulation will be used only near the fluid surface where the complex effect with high visual impact occur. Therefore the most of the fluid domain will be simulated with a fast 2D approach and a fast simulation should be achieved. Erosion Process and Fluid Mixing in 2D SPH We would like to add advection of concentrations between particles to SPH-based shallow water simulation. A 2D representation of the fluid can not fully capture the diffusion and sedimentation processes in the fluid. Therefore we will create new particles by dividing every fluid particle to multiple particles in the vertical direction. These particles will move together in the fluid simulation and will be taken in the computation as a single particle. In the mixing process, where concentrations will be advected, the created particles will be handled as separate particles and carry the dissolved material. The proposed approach to fluid mixing can be exploited in the erosion process as well as in mixing of several fluids. Because several subsamples of dissolved material are stored for every simulation particle a volumetric raytracing can be performed. A realistic visualization of the erosion precess can be acquired in this way. Multiresolution Simulation A multiresolution simulation is usually used to enhance the efficiency of the simulation. In \cite{Adams07} a 3 to 8-times speedup was achieved. Several concepts of particle merging and splitting were used in the resampling process. From two \cite{Adams07} to several particles \cite{Desbrun99} were merged and split. Virtual particles were used in \cite{Keiser06}. Different criterion for particle merging and splitting were used as well. The speed of the deformation was used in \cite{Desbrun99} and the geometrical complexity was used in \cite{Adams07}. A different approach was proposed in \cite{Cohen10}. A translating Eulerian grid was used to to concentrate the computation into important regions and the rest was simulated by particles. This concept can be taken as a level of detail approach as well as the solution from \cite{Solenthaler11}, where a high resolution simulation was used to capture the regions of interest. We would like to employ the multiresolution simulation to concentrate the computation into region

of visual importance. A higher-resolution simulation will be used in this regions. Such regions are the regions where an interaction between fluid and solid occurs. Another criterion will be view dependent criterion based on the field of view of the camera and the distance from the camera. It is difficult to say which resampling solution will perform best for a 2D particle-based simulation. Because of that we will try several solutions and employ the one with best trade-off between speed and stability. Enhancing Sampling of the Fluid A low sampling of the fluid can result in visual artifacts. To resolve this problem in \cite{Ando11} particles were added in the thin fluid regions to prevent rupturing of this regions. A particle was added among two candidate particles and the physical properties were redistributed between the created and candidate particles. This method is employed for the PIC/FLIP method and no such resampling is needed for the 3D SPH because such problem do not occur here.

Cieľ / *Aim*

1. SPH optimization for large fluid dynamics simulation. 2. Study and implement the SPH method implement the terrain as a granular material with different properties. 3. Study the sea dynamics movement.

1. SPH optimization for large fluid dynamics simulation. 2. Study and implement the SPH method implement the terrain as a granular material with different properties. 3. Study the sea dynamics movement.

Literatúra / *Literature*

Minimálne 100 článkov SIGGRAPH, CASA, EG. [1] Lee, H., and Han, S. Solving the shallow water equations using 2d sph particles for interactive applications. Visual Computer 26 (June 2010), 865, 872. [2] Solenthaler, B., and Gross, M. Two-scale particle simulation. ACM Trans. Graph. 30 (Aug. 2011), 81:1, 81:8. and other SIGGRAPH and CSA papers.

At least 100 recent papers from SIGGRAPH a CASA conferences. Starting papers are following: [1] Lee, H., and Han, S. Solving the shallow water equations using 2d sph particles for interactive applications. Visual Computer 26 (June 2010), 865, 872. [2] Solenthaler, B., and Gross, M. Two-scale particle simulation. ACM Trans. Graph. 30 (Aug. 2011), 81:1, 81:8. and other SIGGRAPH and CSA papers.

Poznámka / *Comment*

Možno očakávať, že výsledky dizertácie budú publikovateľné v časopisoch, ktoré pokrýva databáza Mathematical Reviews alebo databáza SCOPUS, SCI napríklad v Computer Graphics Forum, Shape modeling, The Arabian Journal for Science and Engineering, a conferenciach IEEE Information Visualization, ACM SCCG.

Expected publication in scientific journals SCOPUS, SCI for example v Computer Graphics Forum, Shape modeling, The Arabian Journal for Science and Engineering, IEEE Information Visualization, ACM SCCG.

Kľúčové slová / *Keywords*

large fluid simulation, smoothed particle hydrodynamics, shallow water equation, fluid surface, boundary handling

large fluid simulation, smoothed particle hydrodynamics, shallow water equation, fluid surface, boundary handling

Študijný program / *Study programme:*
Geometria a topológia / *Geometry and Topology*

Názov / *Title*
Univerzálny autonómny transportný systém ATS na inteligentnej vozovke
The Universal Autonomous Transport System ATS

Jazyk záverečnej práce / *Language of Thesis*
anglický / *English*

Školiteľ / *Tutor*
prof. RNDr. Roman Ďurikovič, PhD.

Anotácia / *Annotation*
: Automatické dopravné systémy v ohraničenom priestore Ich charakteristickou črtou je použitie výhradne len autonómnych vozidiel a vylúčenie vodičov z ohraničeného priestoru, čo privedie k zvýšeniu poriadku v doprave a výraznému zníženiu počtu dopravných nehôd. Najpokročilejším v tejto kategórii je systém Public Rapid Transport (PRT) od britskej firmy Ultra Global Ltd., ktorý vozí pasažierov na letisku Heathrow od roku 2011 a má pripravených mnoho projektov po celom svete. Existujúce a pripravované systémy tejto kategórie však neriešia dopravu komplexne, ale len v určitých segmentoch dopravy, napr. len osobnú dopravu v špeciálnych vozidlách, alebo len nákladnú dopravu.
ATS requires that we develop a whole new technology "i-vehicles for i-roads" for computer-driven autonomous vehicles. The technology is based on the information interaction between the local navigation system of an on-board computer in the i-vehicle, and passive identifiers on a reconditioned road - the i-road. One of the most important objectives of the ATS introduction as the new transport system is a significant increase in traffic safety. Our goal is a ten-fold reduction in the number of road accidents in the ATS compared with the current average rate of traffic accidents (assuming 100% deployment of computer-controlled vehicles inside the ATS confinement). This ambitious goal is based on the assumption that about 95% of road accidents are caused by drivers, and only a small percentage is a result of technical failures of vehicles. Transport in the ATS will be organized by the Central Control System (CCS). It will be set up in a way to minimize the possible collisions. The CCS will use such means as: strict adherence to the speed limit ruled for each section (curves, intersections, etc.) of the road. The CCS will also ensure smooth and fully controlled switching in between the lanes, thus virtually eliminating emergency situations when overtaking. With the ATS system, seat belt fastening will be mandatory; the vehicle will not move unless all the passengers have been fastened. ATS will eliminate effects of the weather as much as possible. For example, the Central Control System will limit the maximum speed of the vehicles according to the rainfall intensity. ATS developers plan to develop a highly sturdy reading device to receive the information from i-roads that would be as robust and weather proof as possible. Based on preliminary analyses, we plan to develop three-dimensional laser scanning identifiers, little or non-relevant to the water layer on their surface, which will be a few millimeters above the road surface. In the case of normal rainfall (any current traffic situation collapses during a flood situation, usually as a result of vehicle chain accidents) it will be possible to get a high-quality laser-scanned position of the identifier and receive the current vehicle position on the road from its data. The information on the vehicle position shall be read by the detector as many as 5,000 times per second. This way we can acquire a vast redundancy in the flow of information on the vehicle position, compared to the quantity of information on the vehicle position that drivers use nowadays. This suggests that if the vehicle has its location information available many times per second, even if half of this information gets lost, the safety and control of the vehicle movement is still fully sufficient.

Cieľ / *Aim*

A3 Bezpečnosť a spoľahlivosť pohybu systému v ATS (nezávislý výskum a vývoj) A3.1 Analýza súčasného stavu riešenia bezpečnosti a spoľahlivosti autonómnych vozidiel a autonómnych systémov vo svete. A3.2 Analýza externých rizík: výskyt ľudí, zvierat, alebo materiálu v dráhe vozidiel, vplyvy počasia, nečistôt na snímanie údajov z i-vozovky a okolia vozidla. A3.3 Analýza metód identifikácie externých prekážok (výskyt ľudí, zvierat, alebo materiálu v dráhe vozidiel) a metód reakcie systému. A3.4 Výskum metód na predchádzanie stretu s detegovanými prekážkami. A3.5 Výskum zabezpečenia optimálnej komunikácie medzi Bezpečnostným Systémom (BS) a ostatnými systémami vozidla (NS a riadiaci systém). A3.6 Analýza a výskum možností hardvérového riešenia BS. A3.7 Výskum riešenia bezpečnostného systému i-vozidla a jeho integrácie do i-vozidla. A3.8 Výskum vplyvov počasia na spoľahlivosť a bezpečnosť navigačného a bezpečnostného systému ATS A3.9 Implementácia metód bezpečnosti a spoľahlivosti v systéme ATS. A3.10 Integrácie metód bezpečnosti a spoľahlivosti do systému ATS. A3.11 Testovanie a overenie metód bezpečnosti a spoľahlivosti v systéme ATS. A1 Centrálny riadiaci systém, navigačný systém vozidla a možnosti integrácie ATS (základný výskum) A1.1 Analýza súčasného stavu podobných úloh vo svete. A1.2 Definícia požiadaviek a vypracovanie návrhu optimálneho riešenia riadenia systému ATS. A1.3 Výskum virtuálnej reprezentácie priestoru ATS pre centrálny počítač. A1.4 Výskum komplexného efektívneho riadenia dopravy v ATS centrálnym počítačom s rešpektovaním pravidiel dopravy. A1.5 Výskum efektívneho riešenia havarijných a nepredvídaných udalostí na úrovni ATS (blokovanie vozovky, úplná alebo čiastočná strata komunikácie a pod.). A1.6 Výskum efektívneho riadenia dopravy v ATS centrálnym počítačom so softvérom "operational management". A1.7 Vytvorenie virtuálneho modelu ATS a simulácia jeho funkčnosti s mnohými vozidlami v ohraničených areáloch. A1.8 Výskum zabezpečenia optimálnej komunikácie medzi NS a ostatnými systémami vozidla (bezpečnostný systém a riadiaci systém). A1.9 Výskum optimálnej navigácie vozidla riadeného riadiacim systémom. A1.10 Vývoj virtuálnej reprezentácie priestoru ATS pre NS. A1.11 Výskum metód na zabezpečenie dodržania bezpečných vzdialeností v bežnej premávke aj pri havarijných situáciách, automatického plynulého prechodu križovatiek a automatického radenia vozidiel a automatického parkovania. A1.12 Analýza a výskum možností hardwarového riešenia NS. A1.13 Výskum metód uchovania údajov pre potreby analýz v prípade nehody („čierna skrinka“).

The proposed ATS is a new universal autonomous comprehensive transport system, in which the industrially-manufactured electric vehicles of all types (cars, buses, trucks etc.) will be moving about within a bounded area on reconditioned existing roads, without drivers, and only guided by on-board computers. ATS is based on the original technology “intelligent vehicles on intelligent roads” designed by prof. Branislav Sitár. • Highly organized transport constantly controlled by a central control system • The system combines the benefits of individual mobility while maintaining the benefits of public transport • Modularity - local ATS systems can be easily combined into larger units The goals of continuous research on the project: A3 Safety and reliability of the ATS movement system (independent research and development) Analysis of the current status of safety and reliability of autonomous vehicles and autonomous systems in the world. Analysis of external risks: the prevalence of people, animals or materials in the course of the vehicle, weather conditions, dirt for the purposes of monitoring information on the i-road and around the vehicle. Analysis of methods for the identification of external obstacles (presence of humans, animals or materials in the vehicle) and methods of response. Research on methods of preventing collision with the detected obstacles. Research to ensure optimal communication between safety systems (BS) and other vehicle systems (NS and control system). The analysis and research into the hardware solution of safety systems. Research on the security system solution of the i-vehicle and its integration into the i-vehicle. Research on the effects of weather conditions on the reliability and safety of the navigation and security system of ATS

Literatúra / *Literature*

[1] Virtual assistants and self-driving cars - IEEE Conference Publication ieeexplore.ieee.org/document/7972192/ by G Lugano - ⁦2017 [2] Increasing Fairness by Delegating Decisions to Autonomous Agents www.ifaamas.org/Proceedings/aamas2017/pdfs/p419.pdf May 8, 2017 [3] Towards social autonomous vehicles: Efficient collision avoidance ... journals.plos.org/plosone/article?id=10.1371/journal.pone.0186103 by F Riaz - ⁦2017 [4] Proceedings of the 16th Conference on Autonomous Agents and ... dl.acm.org/citation.cfm?id=3091125 May 12, 2017 - AAMAS 2017 [5] Designing Autonomous Vehicles - arXiv https://arxiv.org/pdf/1708.01925 by F Riaz - ⁦2017 [6] A Rational Agent Controlling an Autonomous Vehicle: Implementation ... https://arxiv.org › cs by LER Fernandes - ⁦2017 Mnohé svetové firmy (Google, GM, Ford, Tesla, BMW, Merceds Benz) a ďalšie automobilky v tomto smere už intenzívne pracujú. Na bežné vozidlá pripevnia optické kamery, radary a lidary a palubnými počítačmi riadia vozidlá po obyčajných vozovkách. Tento systém je relatívne málo efektívny, drahý a pomalý. Je otázne, kto bude kupovať počítačom riadené vozidlo, ak bude 2-3 krát drahšie ako bežné auto. Súčasné používanie bezpilotných vozidiel spolu s vozidlami riadenými vodičmi, ktoré medzi sebou nekomunikujú, môže skôr zvýšiť chaos na cestách a tým aj počet dopravných nehôd. Študent si naštuduje a urobí prehľad v priemyselnej oblasti a u konkurencie, zároveň naštuduje odborné články IEEE CS z oblasti riadenia, komunikácie a strojového učenia. Minimálne 100 článkov

[1] Virtual assistants and self-driving cars - IEEE Conference Publication ieeexplore.ieee.org/document/7972192/ by G Lugano - ⁦2017 [2] Increasing Fairness by Delegating Decisions to Autonomous Agents www.ifaamas.org/Proceedings/aamas2017/pdfs/p419.pdf May 8, 2017 [3] Towards social autonomous vehicles: Efficient collision avoidance ... journals.plos.org/plosone/article?id=10.1371/journal.pone.0186103 by F Riaz - ⁦2017 [4] Proceedings of the 16th Conference on Autonomous Agents and ... dl.acm.org/citation.cfm?id=3091125 May 12, 2017 - AAMAS 2017 [5] Designing Autonomous Vehicles - arXiv https://arxiv.org/pdf/1708.01925 by F Riaz - ⁦2017 [6] A Rational Agent Controlling an Autonomous Vehicle: Implementation ... https://arxiv.org › cs by LER Fernandes - ⁦2017 Machine learning research papers from IEEE database. At least 100 recent papers related to autonomous agents and autonomous cars.

Poznámka / *Comment*

Výsledky prace budú publikované v karentovanom časopise a zahraničných časopisoch ako sú JAMSI, IEEE Information Visualization, IEEE Transport systems.

Applicant is expected to publish the WoS journal publications and present the results at international conferences such as JAMSI, IEEE Information Visualization, IEEE Transport systems, local conference Aplimat or other related to the topic.

Kľúčové slová / *Keywords*

autonómne autá, inteligentná vozovka

Autonomous cars, inteligent road