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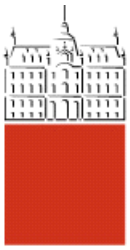

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UMEŠČANJE MODELOV VODNIH SISTEMOV V NAVIDEZNO OKOLJE

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WATER SYSTEM MODELS IN VIRTUAL ENVIRONMENT

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Izvleček

Elemente vodnih sistemov ne moremo prikazovati s prostorskimi podatki, ki predstavljajo konstantno geometrijo. Trirazsežna abstrakcija, skozi katero lahko pregledujemo prostorske podatke o vodnih telesih, je sestavljena iz dinamičnih struktur s kompleksno geometrijo in topologijo. Trirazsežna upodobitev površin ne zadošča pomenskim opredelitvam posameznih elementov prostora, v katerega se vključujejo vodni sistemi.

Pravila oblikovanja vodnogospodarskih vsebin na kartah so nastajala desetletja. Z razvojem novih informacijskih tehnologij upravljanja s prostorskimi podatki in zmožnostmi prikazovanja (3R GIS in navidezna resničnost) pa je treba tudi za vodnogospodarske vsebine izdelati vizualni in vsebinski preskok umeščanja vodnih sistemov v informacijska okolja. Doktorska disertacija obravnava načela umeščanja elementov vodnih sistemov v navideznem okolju in podaja načine pomenskega opredeljevanja elementov vodnih sistemov v trirazsežnem okolju.

Opredeljen je pojem modela vodnega sistema in navideznega okolja, kot univerzalnega trirazsežnega okolja, izdelanega z informacijsko tehnologijo, ki omogoča obravnavo novih razsežnosti vodnih sistemov (npr. realistična upodobitev, čas, ipd.). Ključne opredelitve izhajajo iz matematičnih in fizičnih modelov vodnih sistemov, saj naj bi se v navideznem okolju podatki o stanju vodnih sistemov in rezultati modeliranja združevali v enotnem okolju.

Z metodo razvrščanja vodnih sistemov po objektnih tipih so podrobneje analizirani elementi vodnih pojavov v trirazsežnem prostoru, nato pa opredeljen bistveni element vodnih pojavov v navideznem okolju – vodno telo. Vodnogospodarski objekti, naprave, ureditve in pravni režimi so analizirani kot grajeno okolje, pri katerem so geometrijske lastnosti določene.

Rešitve so preizkušene na praktičnih primerih v navideznem okolju morja, rečnega območja in za dinamiko zaporničnih elementov. Poudarek v doktorski disertaciji je na določitvi vsebine elementov vodnih sistemov in ne na tehnološki rešitvi.

BIBLIOGRAPHIC-DOKUMENTALISTIC INFORMATION

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Abstract

The water system elements can not be illustrated with spatial data with constant geometry. A three-dimensional abstraction, through which spatial data on water bodies can be examined, is composed of dynamic structures with complex geometry and topology. A three-dimensional visualisation of surfaces does not suffice to define the meaning of individual elements of space in which water bodies are included.

Maps rules for water management contents have been drawn for decades. Due to the development of new information technologies for spatial data management and to possibilities of presentation (3D GIS and virtual reality), it is necessary to make a visual and material shift with placing water systems into information environments also as regards water management contents. The thesis deals with the principles of placing water system elements in virtual environment and presents the methods of defining the meaning of water system elements in three-dimensional environment.

It defines the notion of a water system model and virtual environment as universal three-dimensional environment created with information technology which allows treatment of new dimensions of water systems (e.g. realistic presentation, time, etc.). Key definitions are derived from mathematical and physical models of water systems, since in virtual environment the data on water system situation and the results of modelling should be union in the same environment.

Using the method of classifying waters systems by object types, elements of water phenomena are analysed in more detail in three-dimensional space, then an essential element of water phenomena is defined in virtual environment – water body. Water management facilities, installations, arrangements and legal systems are analysed as built environment with defined geometrical properties.

The solutions are tested on practical examples in virtual environment of a part of the sea, river section and dynamics of gate elements. The thesis gives emphasis on the determination of contents of water system elements and not on the technological solution.

POVZETEK

Oblikovanje vodnogospodarskih vsebin na kartah se je razvijalo desetletja. Z razvojem novih informacijskih tehnologij upravljanja s prostorskimi podatki in zmožnostmi prikazovanja pa je potrebno tudi za vodnogospodarske vsebine izdelati vizualni in vsebinski preskok umeščanja vodnih sistemov v različna informacijska okolja. Doktorska disertacija obravnava načela umeščanja elementov vodnih sistemov v navidezno okolje in podaja načine opredeljevanja elementov vodnih sistemov v trirazsežnem okolju.

Opredeljen je pojem modela vodnega sistema in pojem navideznega okolja, kot univerzalnega trirazsežnega okolja, izdelanega z informacijsko tehnologijo, ki omogoča obravnavo novih razsežnosti vodnih sistemov (npr. realistična upodobitev, čas ipd.). Ključne opredelitve izhajajo iz matematičnih in fizičnih modelov vodnih sistemov, saj naj bi se v navideznem okolju izmerjeni podatki o stanju vodnih sistemov in rezultati modeliranja združevali v enotnem okolju.

V zadnjih letih je razvoj prostorskih informacijskih sistemov napovedal naslednjo generacijo uporabe podatkov – trirazsežnih geometrijskih podatkov (npr. 3R CAD, 3R GIS ipd.). Prehod iz dvorazsežne v trirazsežno obravnavo geometrijskih podatkov ni povsem enostaven in tekoč, saj zahtevajo objekti v trirazsežnem prostoru drugačno obravnavo. Vodni sistemi so zaradi prepletanja procesov, ki se v njih dogajajo, in interakcije z okoljem, zelo kompleksni pojavi, zato je za razumevanje le-teh treba uporabiti temu primerno napredna orodja. Navidezno okolje lahko ponudi zelo naravna okolja za upodabljanje znanstvenih podatkov, ki so lahko vključeni v modele okolja, na katere se nanašajo oz. v katerem se nahajajo. Trditev je na primeru vodnih pojavov dokazana s konceptualnim modelom vodnih sistemov v navideznem okolju. Z razvitim konceptualnim modelom, v katerem je najpomembnejši objekt trirazsežnega prostora "vodno telo", je prikazana in verificirana metodologija obravnave elementov vodnih pojavov v trirazsežnem prostoru. Uporaba metodologije dokazuje, da je potrebno obravnavati vodne sisteme v trirazsežnem okolju, saj je možno s prostorskimi funkcijami prikazati vse elemente v prostoru, ki so bistveni za gospodarjenje z vodami. Preverjanje zasnove in metodologije je bila opravljeno za poplavna območja, ko vodno telo visokih voda naleže na zemeljsko površje, razsežnost vodnega telesa pa je odvisna od masnega pretoka (vode, sedimentov). Ker vodno telo obravnavamo kot telo v prostoru, je ustrezen prikaz gladine ploskev odvisen od dejanskih ali modeliranih vrednosti oz. procesov. Izdelana metodologija umestitve modelov vodnih sistemov v navidezna okolja prav tako omogoča tudi nove načine preučevanja skladnosti med izmerjenimi in modeliranimi podatki o vodnih sistemih.

V navidezno okolje umeščeni vodni sistemi omogočajo obravnavo vodnih tokov brez diskontinuitet, kar v dosedanjih dvorazsežnih prikazih (npr. GIS, CAD) ni bilo uspešno modelirano. Obravnava modelov vodnih sistemov z neprekinjenostjo vodnega toka v navideznem okolju omogoča poglobljene raziskave o obnašanju sistema in o relacijah z okoljem, saj je upoštevanje zakona o ohranitvi mase (kontinuitetna enačba) eden od osnovnih pogojev za obravnavo toka vode.

Rezultati metodologije prikazujejo, da je možen preskok iz obstoječih pristopov in sistemov za ravnanje s podatki o vodnih sistemih, ki slonijo predvsem na dvorazsežnem prikazovanju, na dinamična trirazsežna navidezna okolja, in da je z definiranim vodnim telesom mogoče odkrivanje novih znanj o vodnih sistemih in, v povezavi s sistemi drugih področij, ta znanja prenašati tudi v druge znanstvene discipline, ko se obravnava npr. vplive spreminjanja razsežnosti (in s tem globine vode) na favno in floro, ali pa pri rabi novejših metod hidravličnega modeliranja, kot je metoda Smoothed Particle Hydrodynamics Theory ipd. Prikazana vključitev časovne dimenzije v statične elemente navideznega okolja bo omogočala tudi preglednejše zaznavanje obnašanja vodnega sistema znotraj samega vodnega sistema in nasproti drugim sistemom.

Razvit konceptualni model umeščanja modelov vodnih sistemov je verificiran na praktičnih primerih: upodobitve pravnih režimov morja, ugotavljanje skladnosti izmerjenih in modeliranih količin na primeru odseka vodotoka ter na primeru dinamičnega modela prelivnih polj HE Vrhovo s prikazom obratovanja zapornic.

SUMMARY

Maps with water management contents have been drawn for decades. Due to the development of new information technologies for spatial data management and to possibilities of presentation (3D GIS and virtual reality), it is necessary to make a visual and material shift with placing water systems into various information environments also as regards water management contents. The thesis deals with the principles of placing water system elements in virtual environment and presents the methods of defining the meaning of water system elements in three-dimensional environment.

It defines the notion of a water system model and virtual environment as universal three-dimensional environment created with information technology which allows treatment of new dimensions of water systems (e.g. realistic presentation, time, etc.). Key definitions are derived from mathematical and physical models of water systems, since in virtual environment the data on water system situation and the results of modelling should be union in the same environment.

In the last few years, the development of information systems announced the next generation of the use of data – three-dimensional geometrical data (e.g. 3D CAD, 3D GIS, etc.). Passing from two-dimensional to three-dimensional treatment of geometric data is not quite so simple and fluent since objects in three-dimensional space require different treatment. Due to intertwined processes, which occur in them, and their interactions with the environment, water systems are complex phenomena, therefore their understanding requires suitably advanced tools. Virtual environment can offer very natural environments for visualisation of scientific data which can be included into models of environment to which they relate or in which they are situated. The statement is proved on an example of water phenomena by conceptual model of water systems in virtual environment. The developed conceptual model, in which the most important object of three-dimensional space is a "water body", presents and verifies the methodology of treatment of water phenomena elements in three-dimensional space. The usefulness of the methodology show that a shift from two-dimensional to three-dimensional treatment of water systems is necessary since spatial functions allow presentation of all elements in space, which are essential to water management, Verification of frame in methodology was performed for flood areas, since a water body of high water flow is situated on the earth's surface, while the dimension of a water body depends on the mass flow (water, sediments). Since a water body is treated as a body in space, suitable presentation of a water surface is with surface, depends on real or modelled values. The

elaborated methodology of placing water system models in virtual environments allows also new ways of studying uniformity between measured and modelled data on water systems.

Water systems placed in virtual environment allow treatment of water flow without discontinuity, which in the two-dimensional presentations so far (e.g. GIS, CAD) has not been successfully modelled. Treatment of water system models with water flow continuity in virtual environment allows deep researches on the system behaviour and relations with the environment since taking into account the law of conservation of mass (continuity equation) is one of the basic rules of water flow treatment.

The results of the methodology show that it is possible to make a shift from the existing approaches and systems for water system data management based principally on two-dimensional presentation to dynamic three-dimensional virtual environments, since a model describing water bodies allows acquiring new knowledge on water systems and, in relation to systems from other areas, transferring this knowledge to other scientific disciplines, when dealing with impacts of changing dimensions (and thus water depth) on fauna and flora or using the latest methods of hydraulic modelling in water bodies, such as Smoothed Particle Hydrodynamics Theory, etc. The presented inclusion of time dimension in statistical elements of virtual environment will also allow more transparent perception of water system within the water system itself and against other systems.

The developed conceptual model of placing of water system models is verified on practical examples of visualisation of legal systems of the sea, as regards the uniformity of measured and modelled quantities, on an example of a river section and on example of dynamic model of HPP Vrhovo spillway operation.