Committee for Water Resources Management of the Polish Academy of Sciences

Centre for Environmental Engineering and Mechanics

Institute of Hydro-Engineering of the Polish Academy of Sciences

XXV International School of Hydraulics

Hydraulic and Environmental Problems in Open Channel Flows in View of Water Framework Directive

Debrzyno, Poland
September 12–16, 2005

Editor W. Majewski

Gdańsk, September 2005

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CONTEMPORARY METHODS OF THE FLOOD FLOWS HYDRODYNAMIC MODELLING

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ABSTRACT

The hydraulic models can be divided into one-, two-, and three-dimensional. Regardless of the chosen modelling method, it is required to state many parameters which condition correctness and quality of modelling. The principal aim of defining the high wave flows is to describe the characteristics of the valley such as an area cover. Contemporary methods of collecting and processing data afford the opportunity to estimate the resistance parameter of the high wave flows on a large scale. In this paper authors have presented a short review of modern modelling methods. They have also shown their own method of resistance factor identification, using remote sensing, neural networks and texture analysis.

THE REVIEW OF MODERN MODELLING METHODS

Depending on numbers of coordinates required to describe a flow, hydraulic models can be divided into one-, two-, and three-dimensional. Assuming that the flow is one-dimensional, the description of modelling area can be done with cross-sections which should be perpendicular to the flow direction in a geometric or kinematic sense (Radczuk et al 2001). In such models the description of flow is a function of distance x and time t. Most of the applied modelling systems contain 1D models (e.g. HEC-RAS made in the US Army Corps of Engineers, Hydraulic Engineering Center). The two-dimensional description of flow is perhaps rarely done, but also widespread. Unlike the 1D modelling, parameters depend here not only upon time t and distance x but also the y coordinate. In this case the description of a flow area can be defined with a digital terrain model (DTM).

An example of modelling systems including 2D models is SMS (The Surface Wate Modelling System). Even though any physical flow is generally three-dimensional problems with calculating the 3D models of river flow are seldom used.

However, all approaches required numerous data on the flow area. The resistance factoı which mainly depends on the land cover type, belongs to the most important features oí the high wave flow territory.

RESISTANCE FACTOR IDENTIFICATION

In the hydraulic modelling of the swell flows flood area properties affect many essential features like flow velocity, water level, valley capacity. The land cover and its use become very important in case of flood and should be taken into consideration during model building. Especially, while assessing the high wave flow bed capacity it is difficult to describe the parameter of lichen vegetation which determines the value of the partial resistance factor beyond the proper river bed which is a component of the whole flow resistance. The value of normalized resistance factors for some standard surfaces have been put into tables (Ven Te Chow tables). The data which are essential for estimating the vegetation influence on the flow can be received directly, for instance, during the cross-section surveys or remotely, from aerial photos, while DTM is developed. Satellite images can also be very useful and contain much information. However, a wide range of investigative area disqualify the direct and remote although manual techniques of cover estimating, especially in case of using two-and three-dimensional models. Depending on the data source concerning an area and modelling method, there are many possible solutions to assess its cover.

DATA SOURCES

Photogrammetric and satellite images

The digital terrain model (DTM) and digital surface model (DSM) can be determined by means of the photogrammetric method. In order to do this, photogrammetric aerial photos can be used. During processing the distortion, resulting from the area depression of baseline and a camera rake, is eliminated. An image is converted from a central into rectangular projection. Such a process provides an ortophotomap which is a good data source about area cover and of which the resolution depends on the height of flight. Thanks to photos which are taken with an overlap and the geodetic reference it is possible to create a stereoscopic model on the basis of which the horizontal and vertical coordinate assessment are calculated. DTM and DSM enable estimation of the absolute height of all the objects photographed, especially high vegetations. Photos taken in a visible range of spectrum do not contain much information that would enable the automatic segmentation of the land cover with the use of the teledetectional methods. Their advantage is a large scale, cartometric and relatively low cost.

Now, the resolution of satellite pictures does not differ from aerial photos. By standards they are taken in several spectral channels, thus in a various range of spectrum. This feature of satellite pictures makes them easier to classify. Unfortunately this material is still not easily available and more expensive.

Laser scanning

Laser scanning is a contemporary source of data for DTM developing, which very often ousts the traditional photogrammetric method. It enables to develop DTM and DSM quickly, hence it is a good source of information about relief. However, this method does not require a photo recording, so in order to use it for the assessment of area cover, it has to be provided with such material. The picture recording is done using a digital camera or VHS. Unfortunately, these data are hard to use because of poor quality and difficulty in spatial coordination.

The sources described above have both advantages and drawbacks. All of them make it possible to collect considerable data in a short time and also to use a similar processing methodology of classification in respect of surface roughness. The choice of the method determines the quality of this classification.

AUTOMATIC LAND COVER IDENTIFICATION

The automation of classification process is based on three important items of information taken from teledetectical and photogrammetric sources:

- the colour of single pixel (value of gray level for each RGB channel),
- the texture of picture,
- height of cover.

The research was conducted using photogrammetric photos of the Odra valley in 1:26000 scale financed from the PHARE Program, as well as DTM and DSM based on them. In order to take into account the features which describe the picture's texture, the Gray level co-occurrence matrix method (GLCM) has been used. An artificial neural network works as a classifier.

Neural networks

The artificial neural networks applied were a feed-forward, multi-layer ones trained by means of Standard Back-propagation method using hand-crafted reference data. The computer software used for modelling and training the neural networks was SNNS (Stuttgart Neural Network Simulator) in Linux environment.

Texture features based on GLCM method

Gray level co-occurrence matrices method (GLCM), which estimate image properties related to second-order statistics, have become one of the best known and widely used texture features.

The entry, which is the number of occurrences of the pair of gray levels which are a distance apart in a given direction, is defined as follows:

$$P_{i,j} = \frac{V_{i,j}}{\sum_{i,j=0}^{N-1} V_{i,j}} \tag{1}$$

The symmetrical and normalized co-occurrence matrix reveals certain properties about the spatial distribution of the gray levels in the texture image. The features used in experiments are given below:

- contrast: $$\sum_{i,j=0}^{N-1} P_{i,j}(i-j)^2 \tag{2}$$

- dissimilarity: $$\sum_{i,j=0}^{N-1} P_{i,j} \,|\, i-j \,| \tag{3}$$

- homogeneity: $$\sum_{i,j=0}^{N-1} \frac{P_{i,j}}{1+(i-j)^2} \tag{4}$$

- ASM: $$\sum_{i,j=0}^{N-1} P_{i,j}{}^2 \tag{5}$$

- energy: $$\sqrt{ASM} \tag{6}$$

- entropy: $$\sum_{i,j=0}^{N-1} P_{i,j}(-\ln P_{i,j}) \tag{7}$$

Calculated GLCM features, height of objects and gray-level value of pixels were included into input neural network vector.

Quality measures

For the quality analysis and assessment of classification the confusion matrix $\mathbf{A}=[a_{ij}]$, where a_{ij} is a number of sample pixels from the jth class that have been classified to the ith class, was built. On the basis of A matrix, several coefficients have been proposed (Kubik et al 2004):

- the users accuracy of class i:

$$u_i = \frac{a_{ii}}{a_{ri}}, \quad \text{where } a_{ri} = \Sigma_i\, a_i \quad \text{(sum of } i\text{th row entries)} \tag{8}$$

- the producers accuracy of class i:

$$p_i = \frac{a_{ii}}{a_{ci}}, \quad \text{where } a_{ri} = \Sigma_i\, a_i \ \text{(sum of } i\text{th column entries)} \tag{9}$$

- the overall accuracy:

$$d = \frac{a_{ii}}{a_t}, \quad \text{where } a_{ri} = \Sigma_i\, a_{ci} = \Sigma_i\, a_{ri} \tag{10}$$

-simple kappa coefficient:

$$\kappa = \frac{P_o - P_e}{1 - P_e}, \quad \text{where } P_o = \Sigma_i\, a_{ii}/a_t\ ,\ P_e = \Sigma_i\, (a_{ri}\, a_{ci})/a_t^2 \tag{11}$$

According to the Fleiss (1981) kappa values exceeding 0.75 suggest strong agreement above chance, values in the range of 0.40 to 0.75 indicate fair levels of agreement above chance, and values below 0.4 are indicative of poor agreement above chance levels.

Results

To verify assumptions a number of experiments was performed. The results of training networks simultaneously for all classes on the learning data vector were checked on a different photo. The overall accuracy of these data vector feature classification was 0.871596 and the kappa coefficient was 0.871332. Thus final classification of the area, Taking into consideration the area cover (and indirectly flow resistance) has a very good agreement with the expected result made by expert manually.

CONCLUSIONS

The conception of using modern techniques of getting and processing digital data for hydraulic modelling presented above is a contemporary tendency to connect the achievements of different studies. It is also an attempt of interdisciplinary problem solution. It enables the use of automatic transformation of the estimated factors into the contemporary modelling systems. The connection of teledetection, computer science and hydraulics can be a basis for an appreciable progress in the methodology of elaborating the swell flow models, especially if the range of using them as well as the processing of time and monitoring of changes in the valleys are concerned for taking them into account in the model.

AKNOWLEDGEMENTS

This research was supported in part by the Committee for Scientific Research through grant 5T12E02924.

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WSPÓŁCZESNE METODY HYDRODYNAMICZNEGO MODELOWANIA PRZEPŁYWÓW POWODZIOWYCH

STRESZCZENIE

Modele dynamiczne przepływów można podzielić na jedno, dwu i trójwymiarowe. W zależności od wybranej metody modelowania wymagana jest znajomość wielu parametrów, które warunkują poprawność wyniku modelowania. Niezwykle ważnym zagadnieniem w definiowaniu przepływu wezbraniowego jest określenie charakterystyk pokrycia terenu wpływających na jego szorstkość powierzchniową. Współczesne metody gromadzenia i przetwarzania danych dają możliwość kategoryzacji form pokrycia terenu na dużą skalę. W artykule autorzy przedstawili krótki przegląd współczesnych metod modelowania, a także zaprezentowali własną metodę oceny oporów przepływu w dolinie rzeki wykorzystującą zdjęcia lotnicze, sieci neuronowe oraz analizę tekstur.