應用遺傳演算法與類神經網路於地表地下聯合營運

學生：黃浚瑋　　　　　　　　　　　指導教授：張良正博士

國立交通大學土木工程研究所

摘要

與地下水相關之管理模式，常需整合優選與模擬兩種方法，而傳統模式整合方式可分為崁入法(Embedding Method)與響應矩陣法(Response Matrix Method)，但崁入法會因地下水數值模式變數過多而造成整體計算量大增，響應矩陣法則因線性之假設，無法確切反應非線性水位變化情形，有鑑於此，本研究以地下水數值模式 MODFLOW 產生資料訓練類神經網路，並驗證以類神經網路，在給定抽水量下，進行長期預測地下水位變化之可行性。

本研究發展逐時刻優選之地表地下聯合營運模式，其中應用遺傳演算法串連地表水與地下水兩系統，地表水源與地下水源間之調配原則採用「指標平衡」概念，地下水系統部分則採用前述之類神經網路，地表水系統部分則以線性規劃求解，如此本模式可兼具線性規劃之高計算效率與遺傳演算法可以涵蓋線性與非線性之彈性。

本研究以進一步以前述的模式探討不同的營運方式與控制參數對系統供水效能之影響。研究結果顯示，相較於地表水受水文條件之影響，地下水是穩定的供水來源，因此當地下水系統旬平均抽水量僅佔需求量之 7.48% (112.15 萬噸/旬)時，即可大幅降低缺水指數(SI)。此外，本模式透過不同的地下水分層設計，能夠實施不同強度之地下水使用策略，相較於「地表水先用地下水後供」之營運方式，可提供更彈性的地下水營運方式，若管理得當可大幅降低整體缺水情形。

Applying Genetic Algorithm and Neural Network on the Conjunctive Use of Surface and Subsurface Water

Student：Chun-Wei Huang Advisor：Dr. Liang-Cheng Chang

Department of Civil Engineering

National Chiao Tung University

Abstract

An optimal groundwater management model normally integrates an optimization algorithm with a representative groundwater model that describes the relationship between the stress, the pumping, and the system response, the groundwater head or contaminant concentration. Conventionally, the integration schemes can be classified as embedding method and response matrix method. The embedding method which embeds a simulation model may increase computational loading rapidly, while the response matrix method is not adequate for nonlinear problems such as groundwater flow in unconfined aquifers. Therefore, a Back Propagation Neural Network (BPN) that was trained by using the MODFLOW is applied to simulate the nonlinear dynamic relationship between the pumping and groundwater level for an unconfined aquifer. The BPN not only represent a nonlinear transfer function but also reduce the computational loading.

This work proposed a stepwise optimal management model for conjunctive use of surface and subsurface water. For each time step, the

Genetic Algorithm (GA) integrates a surface water allocation model, a linear programming model, and a groundwater simulation model, the BPN, and computes the optimal allocation of surface and subsurface water. The application of Genetic Algorithm (GA) integrates the linear surface water system with a nonlinear groundwater system, and both systems were solved by high efficient algorithms. The rule curve principle and 'index balance' were applied to regulate the water supply for both the surface water and subsurface water.

Numerical studies using the proposed model have performed to investigate the impact of operation strategies or control parameters on the system performance. Groundwater is less affected by the surface runoff than reservoirs. A small amount but reliable groundwater supply can significantly increase the water supply reliability. Simulation results shown that with only increasing 7.48% of total water demand from groundwater can significantly decrease the shortage index (SI) from 2.93 to 0.50. Besides, this work also demonstrates that extending the principle of 'rule curve' operation to groundwater supply can control the priority of using groundwater and is a flexible and effective strategy for the conjunctive operation of surface and subsurface water supply. With the reduced computing complexity of groundwater simulation and a flexible conjunctive operation rule, the proposed model can be applied to field case and is a valuable tool for the planning of conjunctive use of surface and subsurface water.