Chapter 13
Conjugate Gradient Trained Neural Network for Intelligent Sensing of Manhole Gases to Avoid Human Fatality

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ABSTRACT
Computational Intelligence offers solution to various real life problems. Artificial Neural Network (ANN) has the capability of solving highly complex and nonlinear problems. The present chapter demonstrates the application of these tools to provide solutions to the manhole gas detection problem. Manhole, the access point across sewer pipeline system, contains various toxic and explosive gases. Hence, predetermination of these gases before accessing manholes is becoming imperative. The problem is treated as a pattern recognition problem. ANN, devised for solving this problem, is trained using a supervised learning algorithm. The conjugate gradient method is used as an alternative of back propagation neural network learning algorithm for training of the ANN. The chapter offers comprehensive performance analysis of the learning algorithm used for the training of ANN followed by discussion on the methods of presenting the system result. The authors discuss different variants of Conjugate Gradient and propose two new variants of it.

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INTRODUCTION

The study of Computational Intelligence (CI) enabled us to formulate and/or model real life problems, especially for those problems where statistical modeling is inefficient or infeasible. The first and the primary component of CI is the Artificial Neural Network (ANN). ANN leads the field of CI. Later, bio-inspired computational methods, fuzzy logic and swarm intelligence are contributing their significant role in the field of CI. ANN, a powerful mathematical model inspired by the natural neural network system, is still occupying the central stage in CI. To some extent ANN, like natural neural networks, is able to solve highly complex nonlinear problems. The ANN, as an alternative, may be used for modeling those problems whose statistical modeling may not be erected. Our goal in the course of this chapter is to show the application of ANN and its modeling for a real life problem. For such cases, we have identified manhole gas discrimination/detection problem to be modeled using ANN. The manhole gas detection problem is a critical problem in the sense that, the pattern of gases influencing sensor used for sensing of gases is not only random but also dependent on change in the environment, such as temperature, humidity and pressure. The former is a major concern. The latter one can be exerted by employing supreme quality of sensors for sensing gases. In this chapter, we mention a design of an intelligent sensory system for sensing manhole gases, the design of which is as follows. The proposed intelligent system is having three modules, the first module, viz, the input module comprises gas chamber, the sensor array and data acquisition unit is dedicated for sensing the presence of gases in the manholes. Second module, the intelligent module is the ANN model which receives input from the first module and provides its response to the output module after processing the inputs. In the whole exercise the major tasks are a collection of data sample used in the training of the ANN model and the training of the ANN model itself. The ANN is trained in a supervised manner using the conjugate gradient method. Apart from the problem formulation, ANN training methodologies constitute the major subject to discuss through this chapter.

Chapter Organization

What else would be better to start, with, at first, we define the gas detection problem in section, “the problem”. The subsequent section “survey”, enriched this chapter with an exhaustive literature survey of the gas detection problem. With conclusive remarks on the survey, this section also include a brief note on “our contribution” of this chapter towards the mentioned problem. Subsequently, in section, “the problem formulation”, we discuss the mechanisms employed in formulating the problem as a pattern recognition problem using ANN technique. This section includes, discussion on various methods used, data collection procedures, ANN training prerequisites vide subsections, “material and methods”, “collection and analysis of data samples” and “training prerequisites” respectively. In section “conjugate gradient”, we explore the conjugate gradient method for the training of the ANN devised for gas detection problem. Subsequently, section “performance study”, offers a detailed performance evaluation of the conjugate gradient method used for ANN training (GCNN). This section is followed by sections “discussion” and “conclusion”.

THE PROBLEM

Health hazard is the primary concern nowadays. In every hazardous occupation, precautions are taken to avoid fatality. In this chapter, we address such a problem that may cause health hazard and potent to loss of human life. Such problem is detection of hazardous gases in closed space, especially in manholes, where persons have to work for its maintenance. The manholes are the access points