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Interval algebras and order of magnitude reasoning

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ABSTRACT

Qualitative reasoning has been extended by several authors to encompass reasoning about the order of magnitude of quantities. This paper discusses how interval algebras based on interval arithmetic [9] may form a basis for modelling three schemes for order of magnitude reasoning.

1.0 INTRODUCTION

Qualitative reasoning [1] was introduced as a formalism for reasoning about physical systems that captures many of the features of human reasoning. Qualitative reasoning reduces the quantitative precision of the behavioural descriptions of such systems whilst retaining crucial distinctions. Real valued variables are replaced with qualitative variables which can adopt only a small number of values, usually $+$, 0 and $-$. The behaviour is described in terms of changes in the qualitative value of a number of state variables and their first and second derivatives, and these values are related by means of qualitative differential equations, often called confluences. For example, we write:

$$\begin{aligned} dP_{IN,OUT} + dQ_{*1(V,V)} &= 0 \\ dP_{OUT,SMP} + dF_{*1(S)} + dF_{A(M)} &= 0 \\ dP_{IN,SMP} &= + \end{aligned}$$

to qualitatively describe part of the behaviour of a pressure regulator, where dP is shorthand for dP/dt, the first time derivative of P. In theory there is no reason to limit the information used to just the first two derivatives, but in practice it is extremely difficult to obtain higher order relations. All time derivatives are continuous, so that no variable may jump from one qualitative state to another without passing through any intervening states, and variables are combined by means of combinator tables giving the result of every possible combination of inputs, so for qualitative addition $\oplus$ we have :