1.1 Problem Statement

Although several researches have been done on reversible watermarking using difference expansion scheme, there are still several issues to be addressed. Classic Difference Expansion scheme presented by Tian (2003) has become a benchmark for many researchers to evaluate their works (Wang *et al.*, 2010). The main issue being focused is regarding tradeoff between three major components which are interrelated; embedding capacity, imperceptibility and robustness (Huang *et al.*, 2009; Khodaei *et al.*, 2010). In reversible watermarking many researchers try to improve embedding rate of payload and the same time obtaining acceptable visual quality of watermarked image. Second issue is about situation of overflow and underflow during the embedding of payload. Underflow is a condition where the new pixel value after embedding becomes negative. Non-Underflow is a case whereby underflow situation does not occur. Most of works from previous studies applied formula based on Tian's method. In this formula both selected pixels are transformed and situation of overflow and underflow may occur, when the value of pixel decrease or increase beyond zero and 255 respectively. The third issue is, determining the optimum block size and correlation between embedding rate and visual quality. Not many researchers discuss regarding the optimum of block size to be used during partitioning the image into non-overlapping block and the effect to the embedding rate and visual quality when different block size is applied (Tudoroiu *et al*., 2011).

The limitations of reversible image watermarking are illustrated in the magic triangle, shown in Figure 1.1 (Zhang *et al.*, 2010). Imperceptibility, robustness and capacity are at the corners of this diagram. This figure describes the required trade-off between capacity and robustness, at the same time keeping the quality at the acceptable level. Therefore, if the capacity is the aim to be achieved, its quality will be reduced and vice versa. Although there were some researchers who had ability to improve embedding rate, there are still opportunities to obtain higher capacity at acceptable visual quality (Huang *et al.*, 2009).

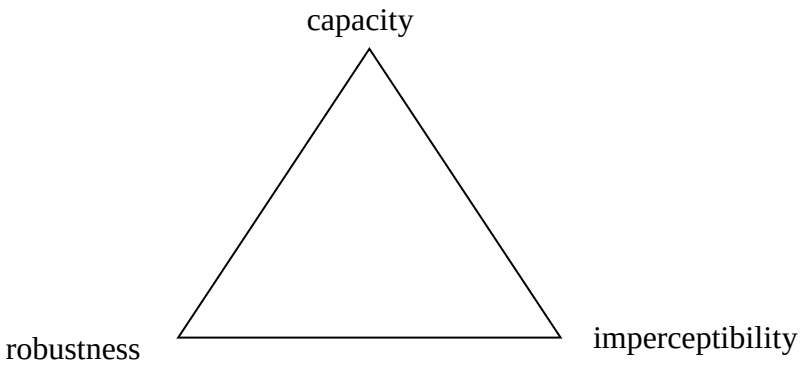

Figure 1.1 Required Tradeoff between Capacity, Robustness and Imperceptibility (Zhang *et al.*, 2010)

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