In VQ design, large codebooks are required for better image quality, while less codebook search and memory are desired for better computational efficiency and compression ratio. In this paper, we present an approach to increase the amount of VQ codebook patterns to improve image quality without a large overhead on the codebook memory and search time.

Basically, our approach characterizes a pattern into a key value, which is used in codebook search. The key value is generated using a centroid method for each vector (block). It represents the angle of a line where the pixel values in the block are distributed with respect to. If the key value is equal to 45 degrees, it implies that the values of the pixels in a block are symmetrically distributed with respect to the diagonal line. "Reflection operation" with respect to diagonal line was performed on codewords using the key values to get more patterns to improve image quality. An extra bit is needed to indicate the reflection operation. Our basic VQ system is a 2-step VQ where VQ is used to compress prediction errors resulting from simple scalar quantization of pixel blocks. The codebook is a sorted list, which is sorted by pattern key values. The search strategy is:

1. Compute the key value for each input vector.
2. Do the binary search to find the entry point according to this key value.
3. Extend the search range around the entry point. The search range is the Voronoi's range. The best matched codeword is chosen for the encoding.

The codebook search time for our technique is $O(\log N + K)$ for each input vector, where $N$ is the codebook size and $K$ is the Voronoi's range.

Comparing to the tree-searched codebook, this codebook design can achieve the performance of the binary tree with less memory. Moreover, since neighbors of a block usually exhibit similar patterns, we use run-length codes to encode reflection bits and thus will not affect compression ratio too much. The memory requirement for our codebook is the same as that without reflection, since reflected codewords are generated during encoding. Our key value approach also gives a sense of "geographical" distribution of pixel values on top of the mean square error criterion, thus provides an improved distortion measure to obtain better image quality.

In conclusion, this technique provides more patterns to improve image quality without a significant overhead on memory and search time.