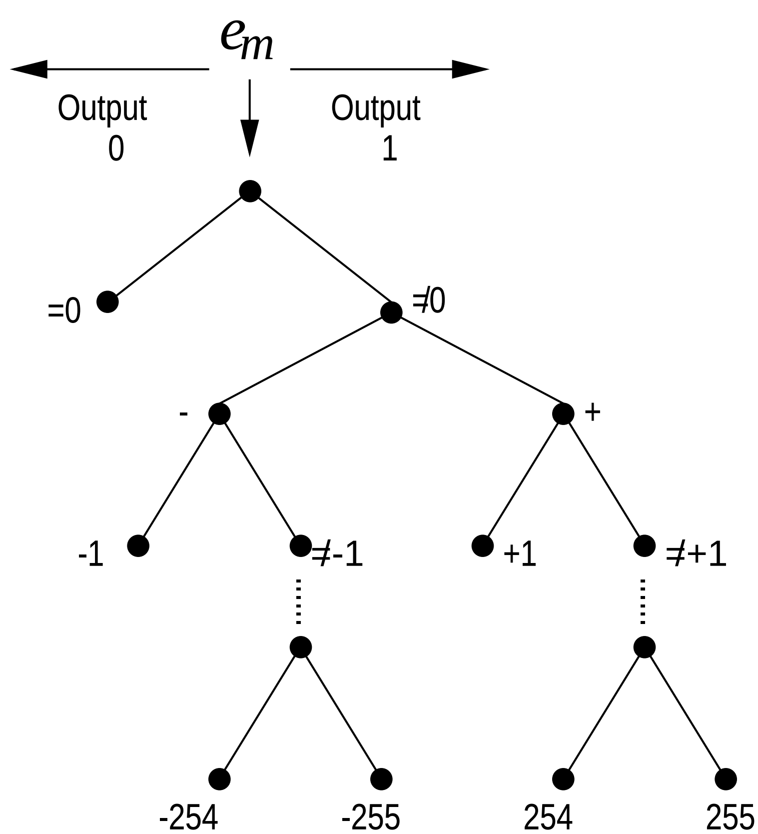
Arithmetic Encoding of Differential Images

- The differential image still slightly correlated
- Adaptive arithmetic coding using contexts further reduces the bit rate
- Most practical implementations of arithmetic coding work only with binary data. A direct application of the Q-coder is not possible since e_m represented by a $K+1$ bit word is not binary.
- Binary decision tree:
  - The quantity to be encoded is determined by a sequence of binary decisions.

– Each binary decision is encoded by the Q-coder using an appropriate context.



- A maximum of 256 binary decisions for any integer e_m: $|e_m| \leq 255$

- Encoding the binary decisions for a given pixel without using contexts $\Rightarrow$ The resulting bit rate is lower bounded by the zeroth-order entropy of the differential image
- The overall entropy for binary decision sequences = Σ entropy for a binary decision node weighted by probability of reaching that node = The zeroth-order entropy of the differential image

– At ($e_m = 0?$):
  * $p(e_m = 0) = \frac{26{,}040}{261{,}121} = 0.100$
  * $H(e_m = 0?)$

$$\begin{aligned} &= -p(e_m = 0)\log_2 p(e_m = 0) \\ &\quad -(1 - p(e_m = 0))\log_2(1 - p(e_m = 0)) \\ &= 0.469 \text{ bit/pixel} \end{aligned}$$

  * $p(\text{reaching at } (e_m = 0?)) = 1.0$

– At ($e_m > 0? | e_m \neq 0$):
  * $p(e_m > 0 | e_m \neq 0) = 0.500$
  * $H(e_m > 0? | e_m \neq 0) = 1$ bit/pixel
  * $p(\text{reaching at } (e_m > 0? | e_m \neq 0))$

$$= p(e_m \neq 0) = 1 - p(e_m = 0)$$
$$= 0.900$$

* $p(\text{reaching at } (e_m = 0?)) \cdot H(e_m = 0?)$
  $+p(\text{reaching at } (e_m > 0?|e_m \neq 0))\cdot$
  $H(e_m > 0?|e_m \neq 0) = 1.369$ bit/pixel
  $\cdots\cdots$

- $H(\text{binary decision sequences}) = 4.56$ bit/pixel
- To achieve this bit rate with an adaptive arithmetic coder, each decision must be encoded under a separate context to account for the different probability estimates for each decision

- To achieve an even lower bit rate, some or all binary decisions must have their outcome probabilities conditioned based on information from the neighboring pixels

Chapter 8
Lossy Plus Lossless Residual Encoding

- Generate a low bit rate image through the use of an efficient lossy compression scheme.
- Form a residual image.
- Encode the residual image using an appropriate lossless technique.
- Progressive transmission and visualization

$$\text{Lossy image} \longrightarrow \begin{array}{l}\text{Lossy image +}\\ \text{residual image}\end{array}$$

- The lossy image constitutes a nonlinear, noncausal prediction.
  - The prediction is not based on previously transmitted information as it is in DPCM and must be explicitly transmitted.
  - Any lossy scheme can be used, but some yield better prediction and/or require less efforts to form the prediction.

- The lossy plus lossless residual approach viewed as a simple two-stage progressive transmission technique
- Adaptive discrete cosine transform (DCT) scheme for lossy compression followed by arithmetic coding for residual