Aruco Marker Detection: Steps and Key Equations

1. **Camera Calibration (Optional)**
   - Find intrinsic camera matrix $\mathbf{K}$ and distortion coefficients by minimizing reprojection error.
2. **Image Acquisition**
   - Capture input image I.
3. **Grayscale Conversion**
   - $I_{\text{gray}} = 0.299R + 0.587G + 0.114B$
4. **Adaptive Thresholding**
   - For each pixel:

$$I_{\text{bin}}(x, y) = \begin{cases} 255 & \text{if } I_{\text{gray}}(x, y) > T_{\text{adaptive}}(x, y) \\ 0 & \text{otherwise} \end{cases}$$

5. **Contour Detection**
   - Extract contours from I_{bin} (e.g., Suzuki-Abe algorithm).
6. **Polygonal Approximation (Douglas-Peucker Algorithm)**
   - Simplify contours: keep points if the perpendicular distance d to the line segment is greater than ϵ.
7. **Candidate Filtering**
   - Keep only polygons with 4 vertices (quadrilaterals).
   - Area thresholding: filter by area A.
   - Convexity check.