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My works:

1. P_1 Nonconforming FE
   -piecewise linear function on quadrilateral element
   -continuous at midpoint of each edge
2. Residual Based A Posteriori Error Estimator for P_1 NCFE

$$\eta^2 := \sum_K h_K^2 \underbrace{\|f + div\nabla u_h^{nc}\|_{0,K}^2}_{\text{cell residual}} + \sum_E h_E \Big(\underbrace{\|J_{E,\nu}\|_{0,E}^2}_{\text{normal jump}} + \underbrace{\|J_{E,\tau}\|_{0,E}^2}_{\text{tangential jump}} \Big) \tag{1}$$

where
$$J_{E,\nu} := \begin{cases} \nu_1 \cdot \nabla u_h^{nc}|_{K_1} + \nu_2 \cdot \nabla u_h^{nc}|_{K_2} & E \in \mathcal{E}(\Omega) \\ g - \nu \cdot \nabla u_h^{nc} & E \in \mathcal{E}(\Gamma_N) \\ 0 & E \in \mathcal{E}(\Gamma_D) \end{cases} \tag{2}$$

$$J_{E,\tau} := \begin{cases} \tau_1 \cdot \nabla u_h^{nc}|_{K_1} + \tau_2 \cdot \nabla u_h^{nc}|_{K_2} & E \in \mathcal{E}(\Omega) \\ 0 & E \in \mathcal{E}(\Gamma_N) \\ \tau \cdot (\nabla u_D - \nabla u_h^{nc}) & E \in \mathcal{E}(\Gamma_D) \end{cases} \tag{3}$$

Consider $-\triangle u = 0$ in $\Omega = [-1,1]^2 \backslash [0,1]^2$
Exact solution in polar coordinate

$$p(r,\theta) = r^{\alpha} \ \sin(\alpha(\theta - \pi/2)) \in H^{1+\alpha}(\Omega), \qquad \alpha = 2/3 \tag{4}$$

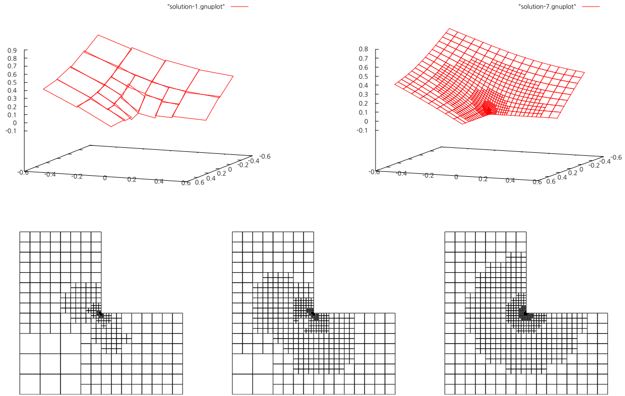

Figure : (Tops) P_1 NCFE Solution w/ tangential term: (L) After 1 refinement, (R) After 7
(Bottoms) Grid after 7 refinements:
(L) Q_1 CFE, (C) P_1 NCFE w/o tangential term, (R) P_1 NCFE w/ tangential term

Further works:

- tangential jump term on Dirichlet boundary edges
- coefficient consideration for the general elliptic problem
- a posterior error estimator for NCFE to another problems