

Równania obserwacyjne w sieciach kątowno-liniowych

ostatnia aktualizacja
29 listopada 2021

Obserwacje kątowno-liniowe

odległość



$$d = \sqrt{(X_k - X_p)^2 + (Y_k - Y_p)^2}$$

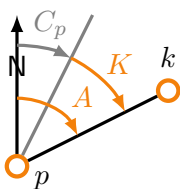
Obserwacje kąto-liniowe

odległość



$$d = \sqrt{(X_k - X_p)^2 + (Y_k - Y_p)^2}$$

kierunek,
azymut



$$A = \arctg \left(\frac{Y_k - Y_p}{X_k - X_p} \right)$$

$$K = \arctg \left(\frac{Y_k - Y_p}{X_k - X_p} \right) - C_p$$

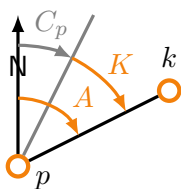
Obserwacje kąto-liniowe

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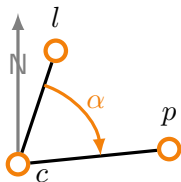
kierunek,
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$$A = \operatorname{arctg} \left(\frac{Y_k - Y_p}{X_k - X_p} \right)$$

$$K = \operatorname{arctg} \left(\frac{Y_k - Y_p}{X_k - X_p} \right) - C_p$$

kąt



$$\begin{aligned} \alpha_{lcp} &= A_{cp} - A_{cl} = K_{cp} - K_{cl} = \\ &= \operatorname{arctg} \left(\frac{Y_p - Y_c}{X_p - X_c} \right) - \operatorname{arctg} \left(\frac{Y_l - Y_c}{X_l - X_c} \right) \end{aligned}$$

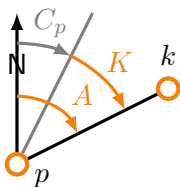
Obserwacje kąto-liniowe

odległość



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kierunek,
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kąt



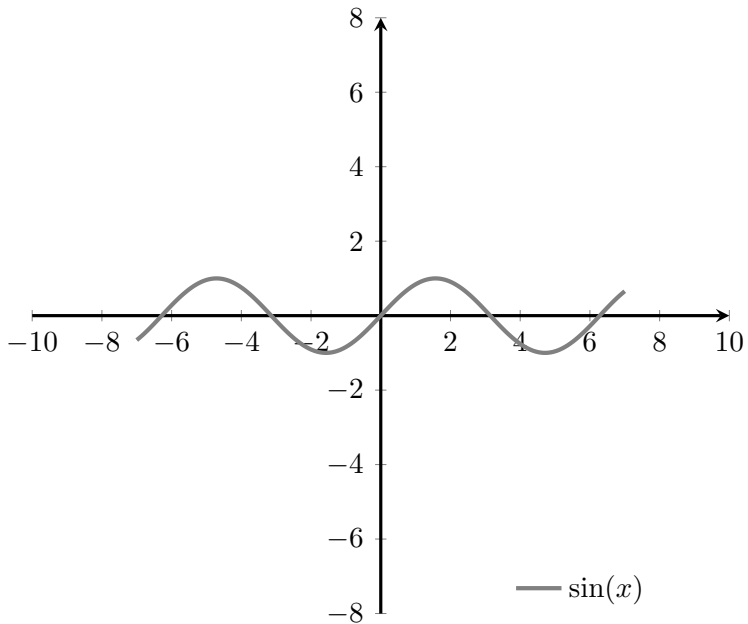
$$\alpha_{lcp} = A_{cp} - A_{cl} = K_{cp} - K_{cl} = \arctg \left(\frac{Y_p - Y_c}{X_p - X_c} \right) - \arctg \left(\frac{Y_l - Y_c}{X_l - X_c} \right)$$

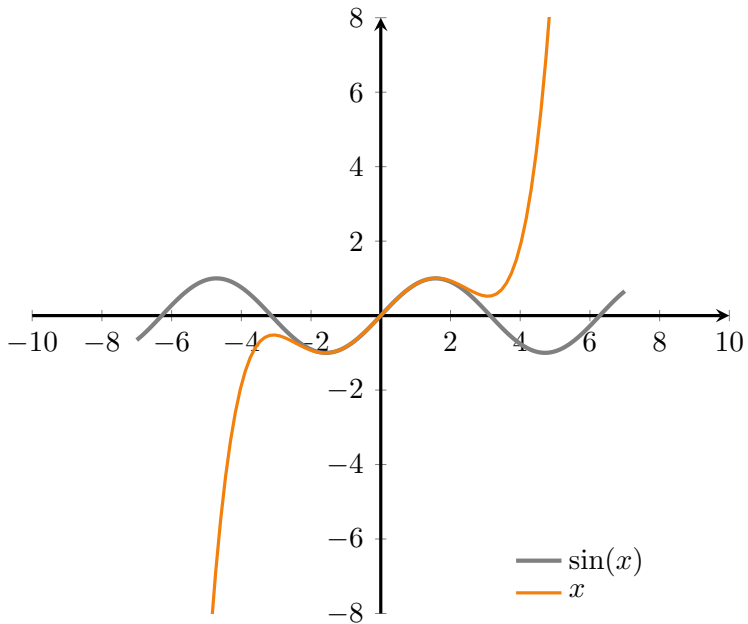
Współrzędne płaskie wszystkich wyznaczanych punktów (X, Y) to niewiadome pośredniczące – elementy wektora niewiadomych. We wszystkich wzorach powyżej niewiadome nie są w postaci liniowej co wyklucza zastosowanie MNK.

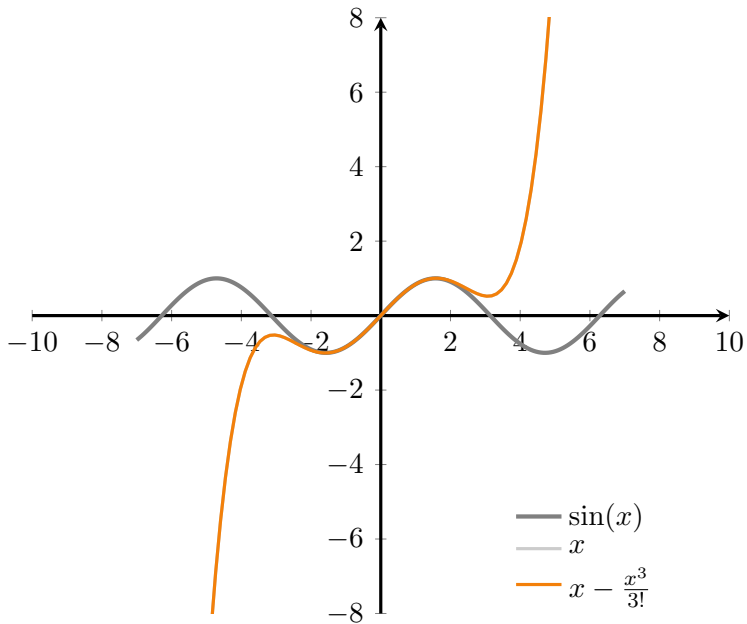
Linearyzacja

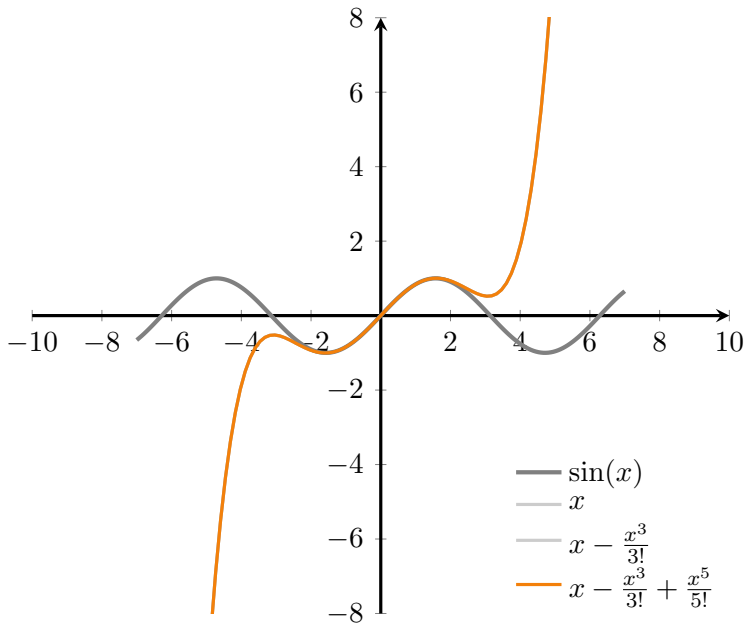
Rozwinięcie funkcji w szereg Taylora

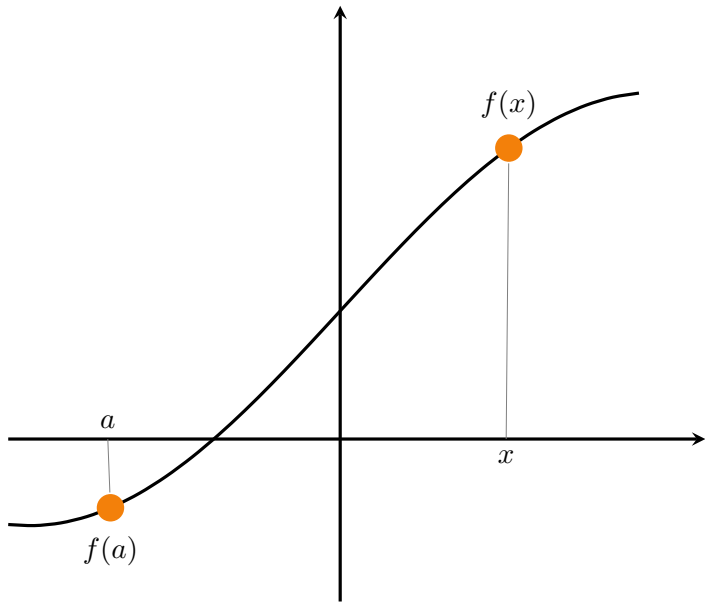
$$\begin{aligned} f(x) &= f(a) + \frac{x-a}{1!} \left. \frac{\partial f}{\partial x} \right|_a + \frac{(x-a)^2}{2!} \left. \frac{\partial^2 f}{\partial x^2} \right|_a \\ &+ \dots + \frac{(x-a)^n}{n!} \left. \frac{\partial^n f}{\partial x^n} \right|_a + R_n(x, a) \\ &= \sum_{k=0}^n \left(\frac{(x-a)^k}{k!} \left. \frac{\partial^k f}{\partial x^k} \right|_a \right) + R_n(x, a) \end{aligned}$$

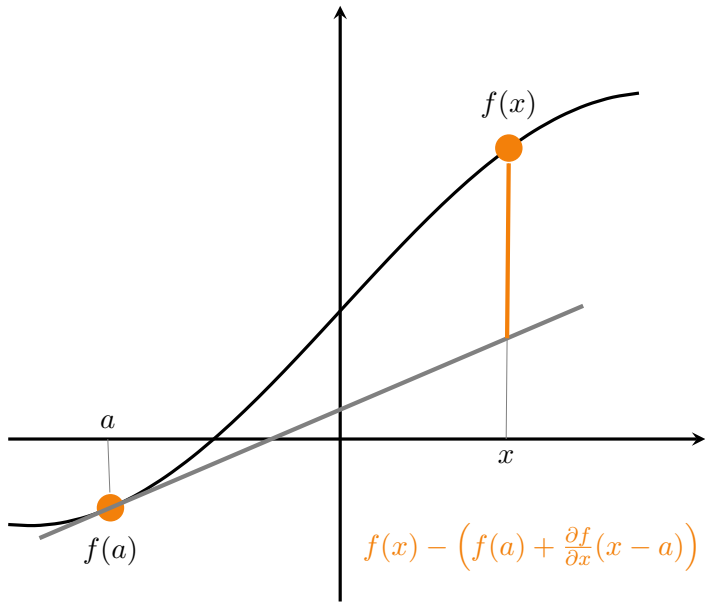


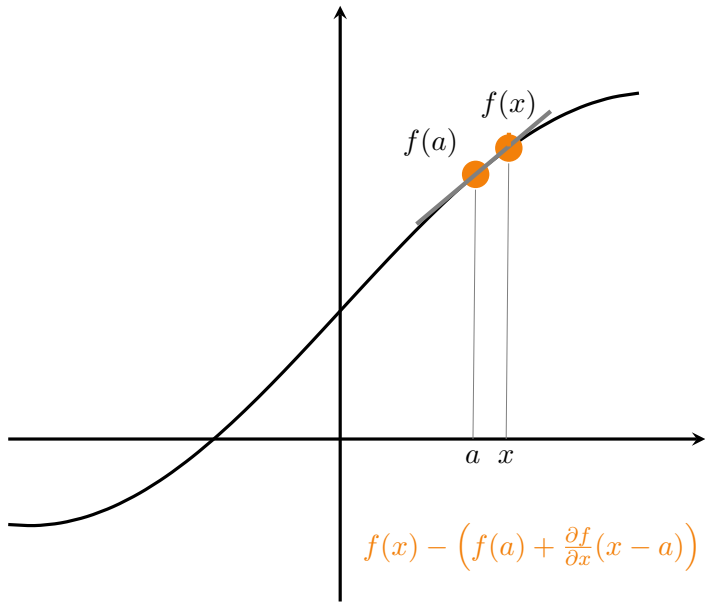













Obserwacje kąto- liniowe

odległość

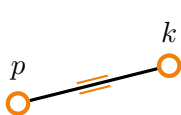

$$d = \sqrt{(X_k - X_p)^2 + (Y_k - Y_p)^2}$$

$$d_{pk}^{obs} + v_{d_{pk}} = d_{pk}$$

$$d_{pk} = d_{pk}^0 + \left. \frac{\partial d_{pk}}{\partial X_p} \right|_{X^0} \Delta X_p + \left. \frac{\partial d_{pk}}{\partial Y_p} \right|_{X^0} \Delta Y_p + \left. \frac{\partial d_{pk}}{\partial X_k} \right|_{X^0} \Delta X_k + \left. \frac{\partial d_{pk}}{\partial Y_k} \right|_{X^0} \Delta Y_k$$

Obserwacje kąto- liniowe

odległość



$$d = \sqrt{(X_k - X_p)^2 + (Y_k - Y_p)^2}$$

$$d_{pk}^0 = \sqrt{(X_k^0 - X_p^0)^2 + (Y_k^0 - Y_p^0)^2}$$

$$\left. \frac{\partial d_{pk}}{\partial X_p} \right|_{X^0} = \frac{-2(X_k^0 - X_p^0)}{2\sqrt{(X_k^0 - X_p^0)^2 + (Y_k^0 - Y_p^0)^2}} = \frac{-\Delta X_{pk}^0}{d_{pk}^0} = -\cos A_{pk}^0$$

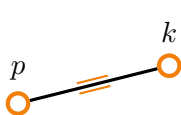
$$\left. \frac{\partial d_{pk}}{\partial Y_p} \right|_{X^0} = \frac{-2(Y_k^0 - Y_p^0)}{2\sqrt{(X_k^0 - X_p^0)^2 + (Y_k^0 - Y_p^0)^2}} = \frac{-\Delta Y_{pk}^0}{d_{pk}^0} = -\sin A_{pk}^0$$

$$\left. \frac{\partial d_{pk}}{\partial X_k} \right|_{X^0} = \frac{2(X_k^0 - X_p^0)}{2\sqrt{(X_k^0 - X_p^0)^2 + (Y_k^0 - Y_p^0)^2}} = \frac{\Delta X_{pk}^0}{d_{pk}^0} = \cos A_{pk}^0$$

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Obserwacje kąto- liniowe

odległość



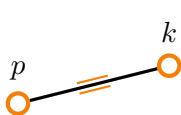
$$d = \sqrt{(X_k - X_p)^2 + (Y_k - Y_p)^2}$$

Równanie poprawki dla odległości

$$\begin{aligned} v_{d_{pk}} = & \\ & = -\cos A_{pk}^0 \cdot \Delta X_p - \sin A_{pk}^0 \cdot \Delta Y_p + \cos A_{pk}^0 \cdot \Delta X_k + \sin A_{pk}^0 \cdot \Delta Y_k + \\ & + d_{pk}^0 - d_{pk}^{obs} \end{aligned}$$

Obserwacje kąto-liniowe

odległość



$$d = \sqrt{(X_k - X_p)^2 + (Y_k - Y_p)^2}$$

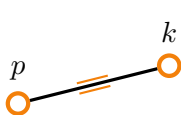
Równanie poprawki dla odległości

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współczynniki przy niewiadomych

Obserwacje kąto-liniowe

odległość



$$d = \sqrt{(X_k - X_p)^2 + (Y_k - Y_p)^2}$$

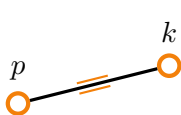
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niewiadome

Obserwacje kąto-liniowe

odległość



$$d = \sqrt{(X_k - X_p)^2 + (Y_k - Y_p)^2}$$

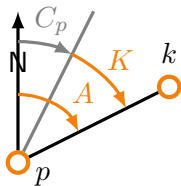
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$$\begin{aligned} v_{d_{pk}} = & \\ & = -\cos A_{pk}^0 \cdot \Delta X_p - \sin A_{pk}^0 \cdot \Delta Y_p + \cos A_{pk}^0 \cdot \Delta X_k + \sin A_{pk}^0 \cdot \Delta Y_k + \\ & \quad + d_{pk}^0 - d_{pk}^{obs} \end{aligned}$$

wyrazy wolne

Obserwacje kąto- liniowe

kierunek,
azymut



$$A = \arctg \left(\frac{Y_k - Y_p}{X_k - X_p} \right)$$

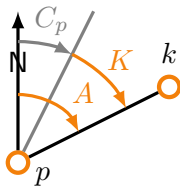
$$K = \arctg \left(\frac{Y_k - Y_p}{X_k - X_p} \right) - C_p$$

$$K_{pk}^{obs} + v_{K_{pk}} = K_{pk} = A_{pk} - C_p$$

$$K_{pk} = K_{pk}^0 + \frac{\partial A_{pk}}{\partial X_p} \bigg|_{X^0} \Delta X_p + \frac{\partial A_{pk}}{\partial Y_p} \bigg|_{X^0} \Delta Y_p + \frac{\partial A_{pk}}{\partial X_k} \bigg|_{X^0} \Delta X_k + \frac{\partial A_{pk}}{\partial Y_k} \bigg|_{X^0} \Delta Y_k - \Delta C_p$$

Obserwacje kątowo-liniowe

kierunek,
azymut



$$A = \operatorname{arctg} \left(\frac{Y_k - Y_p}{X_k - X_p} \right)$$

$$K = \operatorname{arctg} \left(\frac{Y_k - Y_p}{X_k - X_p} \right) - C_p$$

$$A_{pk}^0 = \operatorname{arctg} \frac{(Y_k^0 - Y_p^0)}{(X_k^0 - X_p^0)}$$

$$\left. \frac{\partial A_{pk}}{\partial X_p} \right|_{X^0} = \frac{(Y_k^0 - Y_p^0)}{(X_k^0 - X_p^0)^2 + (Y_k^0 - Y_p^0)^2}$$

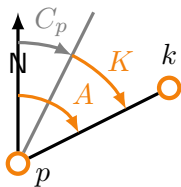
$$\left. \frac{\partial A_{pk}}{\partial Y_p} \right|_{X^0} = \frac{-(X_k^0 - X_p^0)}{(X_k^0 - X_p^0)^2 + (Y_k^0 - Y_p^0)^2}$$

$$\left. \frac{\partial A_{pk}}{\partial X_k} \right|_{X^0} = \frac{-(Y_k^0 - Y_p^0)}{(X_k^0 - X_p^0)^2 + (Y_k^0 - Y_p^0)^2}$$

$$\left. \frac{\partial A_{pk}}{\partial Y_k} \right|_{X^0} = \frac{(X_k^0 - X_p^0)}{(X_k^0 - X_p^0)^2 + (Y_k^0 - Y_p^0)^2}$$

Obserwacje kątowo-liniowe

kierunek,
azymut



$$A = \operatorname{arctg} \left(\frac{Y_k - Y_p}{X_k - X_p} \right)$$

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$$A_{pk}^0 = \operatorname{arctg} \frac{(Y_k^0 - Y_p^0)}{(X_k^0 - X_p^0)}$$

$$\left. \frac{\partial A_{pk}}{\partial X_p} \right|_{X^0} = \frac{\Delta Y_{pk}^0}{(d_{pk}^0)^2}$$

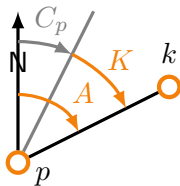
$$\left. \frac{\partial A_{pk}}{\partial X_k} \right|_{X^0} = - \frac{\Delta Y_{pk}^0}{(d_{pk}^0)^2}$$

$$\left. \frac{\partial A_{pk}}{\partial Y_p} \right|_{X^0} = - \frac{\Delta X_{pk}^0}{(d_{pk}^0)^2}$$

$$\left. \frac{\partial A_{pk}}{\partial Y_k} \right|_{X^0} = \frac{\Delta X_{pk}^0}{(d_{pk}^0)^2}$$

Obserwacje kątowo-liniowe

kierunek,
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$$A = \operatorname{arctg} \left(\frac{Y_k - Y_p}{X_k - X_p} \right)$$

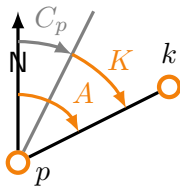
$$K = \operatorname{arctg} \left(\frac{Y_k - Y_p}{X_k - X_p} \right) - C_p$$

Równanie poprawki dla kierunku

$$\begin{aligned} v_{K_{pk}} &= \\ &= \frac{\Delta Y_{pk}^0}{(d_{pk}^0)^2} \cdot \Delta X_p - \frac{\Delta X_{pk}^0}{(d_{pk}^0)^2} \cdot \Delta Y_p - \frac{\Delta Y_{pk}^0}{(d_{pk}^0)^2} \cdot \Delta X_k + \frac{\Delta X_{pk}^0}{(d_{pk}^0)^2} \cdot \Delta Y_k - \Delta C_p + \\ &\quad + A_{pk}^0 - C_p^0 - K_{pk}^{obs} \end{aligned}$$

Obserwacje kąto-liniowe

kierunek,
azymut



$$A = \operatorname{arctg} \left(\frac{Y_k - Y_p}{X_k - X_p} \right)$$

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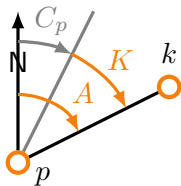
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współczynniki przy niewiadomych

Obserwacje kąto-liniowe

kierunek,
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$$A = \arctg \left(\frac{Y_k - Y_p}{X_k - X_p} \right)$$

$$K = \arctg \left(\frac{Y_k - Y_p}{X_k - X_p} \right) - C_p$$

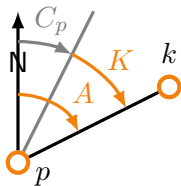
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niewiadome

Obserwacje kąto- liniowe

kierunek,
azymut



$$A = \operatorname{arctg} \left(\frac{Y_k - Y_p}{X_k - X_p} \right)$$

$$K = \operatorname{arctg} \left(\frac{Y_k - Y_p}{X_k - X_p} \right) - C_p$$

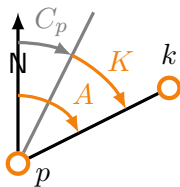
Równanie poprawki dla kierunku

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wyrazy wolne

Obserwacje kątowo-liniowe

kierunek,
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$$A = \operatorname{arctg} \left(\frac{Y_k - Y_p}{X_k - X_p} \right)$$

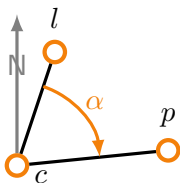
$$K = \operatorname{arctg} \left(\frac{Y_k - Y_p}{X_k - X_p} \right) - C_p$$

Równanie poprawki dla azymutu

$$\begin{aligned} v_{A_{pk}} &= \\ &= \frac{\Delta Y_{pk}^0}{(d_{pk}^0)^2} \cdot \Delta X_p - \frac{\Delta X_{pk}^0}{(d_{pk}^0)^2} \cdot \Delta Y_p - \frac{\Delta Y_{pk}^0}{(d_{pk}^0)^2} \cdot \Delta X_k + \frac{\Delta X_{pk}^0}{(d_{pk}^0)^2} \cdot \Delta Y_k + \\ &\quad + A_{pk}^0 - A_{pk}^{obs} \end{aligned}$$

Obserwacje kątowo-liniowe

kąt



$$\alpha_{lcp} = A_{cp} - A_{cl} = K_{cp} - K_{cl} = \\ = \arctg\left(\frac{Y_p - Y_c}{X_p - X_c}\right) - \arctg\left(\frac{Y_l - Y_c}{X_l - X_c}\right)$$

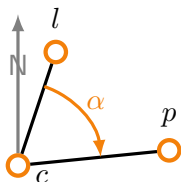
$$\alpha_{lcp}^{obs} + v_{\alpha_{pk}} = \alpha_{lcp}$$

$$\alpha_{lcp} = \alpha_{lcp}^0 +$$

$$+ \frac{\partial \alpha_{lcp}}{\partial X_l} \bigg|_{X^0} \Delta X_l + \frac{\partial \alpha_{lcp}}{\partial Y_l} \bigg|_{X^0} \Delta Y_l \\ + \frac{\partial \alpha_{lcp}}{\partial X_p} \bigg|_{X^0} \Delta X_p + \frac{\partial \alpha_{lcp}}{\partial Y_p} \bigg|_{X^0} \Delta Y_p \\ + \frac{\partial \alpha_{lcp}}{\partial X_c} \bigg|_{X^0} \Delta X_c + \frac{\partial \alpha_{lcp}}{\partial Y_c} \bigg|_{X^0} \Delta Y_c$$

Obserwacje kąto- liniowe

kąt



$$\alpha_{lcp} = A_{cp} - A_{cl} = K_{cp} - K_{cl} = \\ = \arctg\left(\frac{Y_p - Y_c}{X_p - X_c}\right) - \arctg\left(\frac{Y_l - Y_c}{X_l - X_c}\right)$$

$$\alpha_{lcp}^0 = \arctg\left(\frac{Y_p^0 - Y_c^0}{X_p^0 - X_c^0}\right) - \arctg\left(\frac{Y_l^0 - Y_c^0}{X_l^0 - X_c^0}\right)$$

$$\left. \frac{\partial \alpha_{lcp}}{\partial X_l} \right|_{X^0} = \frac{\Delta Y_{cl}^0}{(d_{cl}^0)^2}$$

$$\left. \frac{\partial \alpha_{lcp}}{\partial Y_l} \right|_{X^0} = -\frac{\Delta X_{cl}^0}{(d_{cl}^0)^2}$$

$$\left. \frac{\partial \alpha_{lcp}}{\partial X_p} \right|_{X^0} = -\frac{\Delta Y_{cp}^0}{(d_{cp}^0)^2}$$

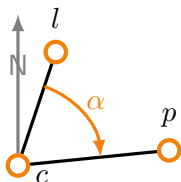
$$\left. \frac{\partial \alpha_{lcp}}{\partial Y_p} \right|_{X^0} = \frac{\Delta X_{cp}^0}{(d_{cp}^0)^2}$$

$$\left. \frac{\partial \alpha_{lcp}}{\partial X_c} \right|_{X^0} = \frac{\Delta Y_{cp}^0}{(d_{cp}^0)^2} - \frac{\Delta Y_{cl}^0}{(d_{cl}^0)^2}$$

$$\left. \frac{\partial \alpha_{lcp}}{\partial Y_c} \right|_{X^0} = -\frac{\Delta X_{cp}^0}{(d_{cp}^0)^2} + \frac{\Delta X_{cl}^0}{(d_{cl}^0)^2}$$

Obserwacje kąto- liniowe

kąt



$$\alpha_{lcp} = A_{cp} - A_{cl} = K_{cp} - K_{cl} = \\ = \arctg\left(\frac{Y_p - Y_c}{X_p - X_c}\right) - \arctg\left(\frac{Y_l - Y_c}{X_l - X_c}\right)$$

$$\alpha_{lcp}^0 = \arctg\left(\frac{Y_p^0 - Y_c^0}{X_p^0 - X_c^0}\right) - \arctg\left(\frac{Y_l^0 - Y_c^0}{X_l^0 - X_c^0}\right)$$

$$\left. \frac{\partial \alpha_{lcp}}{\partial X_l} \right|_{X^0} = \frac{\Delta Y_{cl}^0}{(d_{cl}^0)^2}$$

$$\left. \frac{\partial \alpha_{lcp}}{\partial Y_l} \right|_{X^0} = -\frac{\Delta X_{cl}^0}{(d_{cl}^0)^2}$$

$$\left. \frac{\partial \alpha_{lcp}}{\partial X_p} \right|_{X^0} = -\frac{\Delta Y_{cp}^0}{(d_{cp}^0)^2}$$

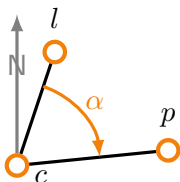
$$\left. \frac{\partial \alpha_{lcp}}{\partial Y_p} \right|_{X^0} = \frac{\Delta X_{cp}^0}{(d_{cp}^0)^2}$$

$$\left. \frac{\partial \alpha_{lcp}}{\partial X_c} \right|_{X^0} = \frac{\Delta Y_{cp}^0}{(d_{cp}^0)^2} - \frac{\Delta Y_{cl}^0}{(d_{cl}^0)^2}$$

$$\left. \frac{\partial \alpha_{lcp}}{\partial Y_c} \right|_{X^0} = -\frac{\Delta X_{cp}^0}{(d_{cp}^0)^2} + \frac{\Delta X_{cl}^0}{(d_{cl}^0)^2}$$

Obserwacje kątowo-liniowe

kąt



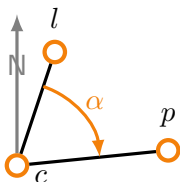
$$\alpha_{lcp} = A_{cp} - A_{cl} = K_{cp} - K_{cl} = \\ = \arctg\left(\frac{Y_p - Y_c}{X_p - X_c}\right) - \arctg\left(\frac{Y_l - Y_c}{X_l - X_c}\right)$$

Równanie poprawki dla kąta

$$v_{\alpha_{pk}} = \\ = \frac{\Delta Y_{cl}^0}{(d_{cl}^0)^2} \cdot \Delta X_l - \frac{\Delta X_{cl}^0}{(d_{cl}^0)^2} \cdot \Delta Y_l - \frac{\Delta Y_{cp}^0}{(d_{cp}^0)^2} \cdot \Delta X_p + \frac{\Delta X_{cp}^0}{(d_{cp}^0)^2} \cdot \Delta Y_p + \\ + \left(\frac{\Delta Y_{cp}^0}{(d_{cp}^0)^2} - \frac{\Delta Y_{cl}^0}{(d_{cl}^0)^2} \right) \cdot \Delta X_c + \left(-\frac{\Delta X_{cp}^0}{(d_{cp}^0)^2} + \frac{\Delta X_{cl}^0}{(d_{cl}^0)^2} \right) \cdot \Delta Y_c + \\ + \alpha_{lcp}^0 - \alpha_{lcp}^{obs}$$

Obserwacje kąto- liniowe

kąt



$$\alpha_{lcp} = A_{cp} - A_{cl} = K_{cp} - K_{cl} = \\ = \arctg\left(\frac{Y_p - Y_c}{X_p - X_c}\right) - \arctg\left(\frac{Y_l - Y_c}{X_l - X_c}\right)$$

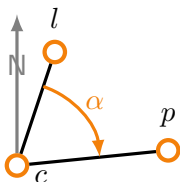
Równanie poprawki dla kąta

$$v_{\alpha_{pk}} = \\ = \frac{\Delta Y_{cl}^0}{(d_{cl}^0)^2} \cdot \Delta X_l - \frac{\Delta X_{cl}^0}{(d_{cl}^0)^2} \cdot \Delta Y_l - \frac{\Delta Y_{cp}^0}{(d_{cp}^0)^2} \cdot \Delta X_p + \frac{\Delta X_{cp}^0}{(d_{cp}^0)^2} \cdot \Delta Y_p + \\ + \left(\frac{\Delta Y_{cp}^0}{(d_{cp}^0)^2} - \frac{\Delta Y_{cl}^0}{(d_{cl}^0)^2} \right) \cdot \Delta X_c + \left(-\frac{\Delta X_{cp}^0}{(d_{cp}^0)^2} + \frac{\Delta X_{cl}^0}{(d_{cl}^0)^2} \right) \cdot \Delta Y_c + \\ + \alpha_{lcp}^0 - \alpha_{lcp}^{obs}$$

współczynniki przy niewiadomych

Obserwacje kątowo-liniowe

kąt



$$\alpha_{lcp} = A_{cp} - A_{cl} = K_{cp} - K_{cl} = \\ = \arctg\left(\frac{Y_p - Y_c}{X_p - X_c}\right) - \arctg\left(\frac{Y_l - Y_c}{X_l - X_c}\right)$$

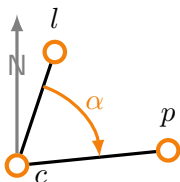
Równanie poprawki dla kąta

$$v_{\alpha_{pk}} = \\ = \frac{\Delta Y_{cl}^0}{(d_{cl}^0)^2} \cdot \Delta X_l - \frac{\Delta X_{cl}^0}{(d_{cl}^0)^2} \cdot \Delta Y_l - \frac{\Delta Y_{cp}^0}{(d_{cp}^0)^2} \cdot \Delta X_p + \frac{\Delta X_{cp}^0}{(d_{cp}^0)^2} \cdot \Delta Y_p + \\ + \left(\frac{\Delta Y_{cp}^0}{(d_{cp}^0)^2} - \frac{\Delta Y_{cl}^0}{(d_{cl}^0)^2} \right) \cdot \Delta X_c + \left(-\frac{\Delta X_{cp}^0}{(d_{cp}^0)^2} + \frac{\Delta X_{cl}^0}{(d_{cl}^0)^2} \right) \cdot \Delta Y_c + \\ + \alpha_{lcp}^0 - \alpha_{lcp}^{obs}$$

niewiadome

Obserwacje kątowo-liniowe

kąt



$$\alpha_{lcp} = A_{cp} - A_{cl} = K_{cp} - K_{cl} = \\ = \arctg\left(\frac{Y_p - Y_c}{X_p - X_c}\right) - \arctg\left(\frac{Y_l - Y_c}{X_l - X_c}\right)$$

Równanie poprawki dla kąta

$$v_{\alpha_{pk}} = \\ = \frac{\Delta Y_{cl}^0}{(d_{cl}^0)^2} \cdot \Delta X_l - \frac{\Delta X_{cl}^0}{(d_{cl}^0)^2} \cdot \Delta Y_l - \frac{\Delta Y_{cp}^0}{(d_{cp}^0)^2} \cdot \Delta X_p + \frac{\Delta X_{cp}^0}{(d_{cp}^0)^2} \cdot \Delta Y_p + \\ + \left(\frac{\Delta Y_{cp}^0}{(d_{cp}^0)^2} - \frac{\Delta Y_{cl}^0}{(d_{cl}^0)^2} \right) \cdot \Delta X_c + \left(-\frac{\Delta X_{cp}^0}{(d_{cp}^0)^2} + \frac{\Delta X_{cl}^0}{(d_{cl}^0)^2} \right) \cdot \Delta Y_c + \\ + \alpha_{lcp}^0 - \alpha_{lcp}^{obs}$$

wyrazy wolne

Obserwacje kąto- liniowe

Równanie poprawki dla odległości

$$v_{d_{pk}} = -\cos A_{pk}^0 \cdot \Delta X_p - \sin A_{pk}^0 \cdot \Delta Y_p + \cos A_{pk}^0 \cdot \Delta X_k + \sin A_{pk}^0 \cdot \Delta Y_k + \\ + d_{pk}^0 - d_{pk}^{obs}$$

Równanie poprawki dla kierunku

$$v_{K_{pk}} = \frac{\Delta Y_{pk}^0}{(d_{pk}^0)^2} \cdot \Delta X_p - \frac{\Delta X_{pk}^0}{(d_{pk}^0)^2} \cdot \Delta Y_p - \frac{\Delta Y_{pk}^0}{(d_{pk}^0)^2} \cdot \Delta X_k + \frac{\Delta X_{pk}^0}{(d_{pk}^0)^2} \cdot \Delta Y_k - \Delta C_p + \\ + A_{pk}^0 - C_p^0 - K_{pk}^{obs}$$

Równanie poprawki dla kąta

$$v_{\alpha_{pk}} = \frac{\Delta Y_{cl}^0}{(d_{cl}^0)^2} \cdot \Delta X_l - \frac{\Delta X_{cl}^0}{(d_{cl}^0)^2} \cdot \Delta Y_l - \frac{\Delta Y_{cp}^0}{(d_{cp}^0)^2} \cdot \Delta X_p + \frac{\Delta X_{cp}^0}{(d_{cp}^0)^2} \cdot \Delta Y_p + \\ + \left(\frac{\Delta Y_{cp}^0}{(d_{cp}^0)^2} - \frac{\Delta Y_{cl}^0}{(d_{cl}^0)^2} \right) \cdot \Delta X_c + \left(-\frac{\Delta X_{cp}^0}{(d_{cp}^0)^2} + \frac{\Delta X_{cl}^0}{(d_{cl}^0)^2} \right) \cdot \Delta Y_c + \\ + \alpha_{lcp}^0 - \alpha_{lcp}^{obs}$$