

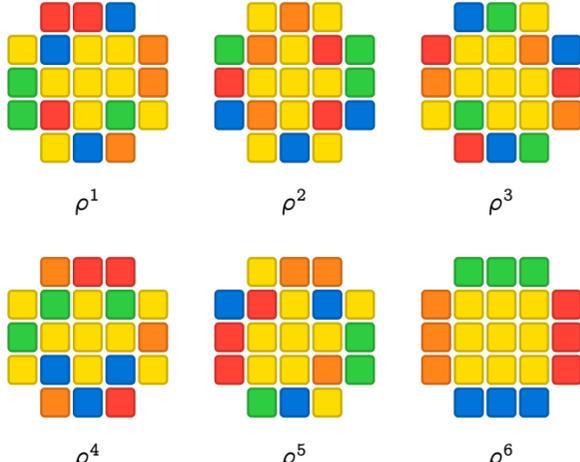
# Cubing Algorithms

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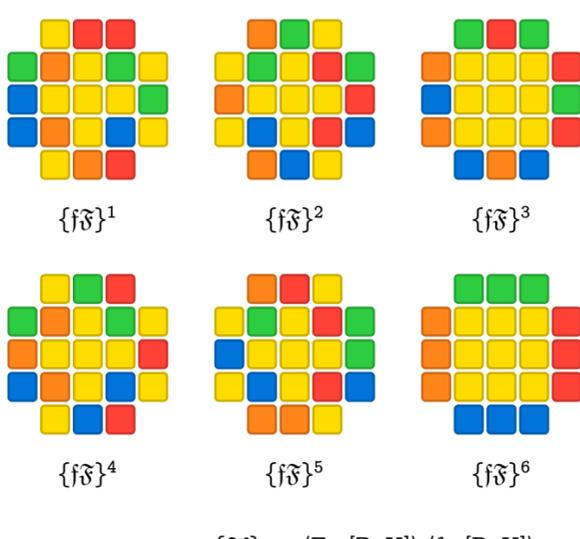
## Orient last layer

$$\rho := \langle R U : [R', U] \rangle = R U R' U R U' U' R'$$

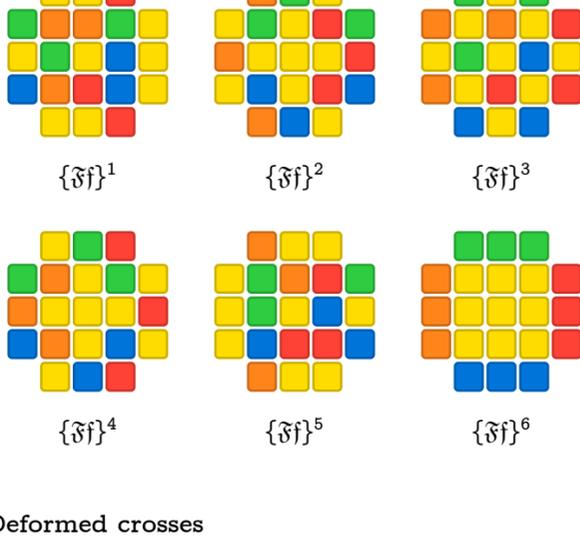


## Crosses

$$\{f\delta\} := \langle f : [R, U] \rangle \langle F : [R, U] \rangle = f R U R' U' f' F R U R' U' F'$$

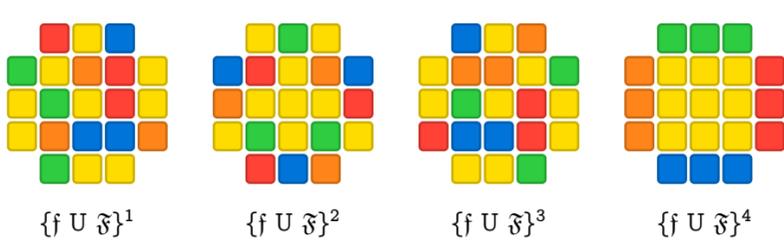


$$\{\delta f\} := \langle F : [R, U] \rangle \langle f : [R, U] \rangle = F R U R' U' F' f R U R' U' f'$$

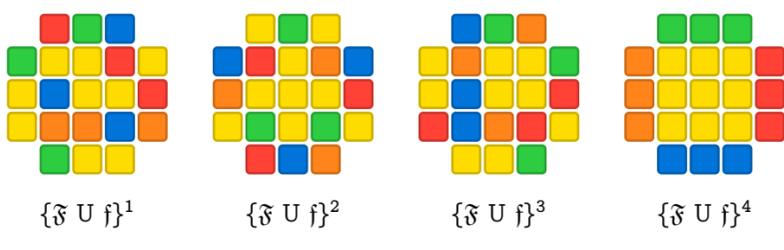


## Deformed crosses

$$\{f X \delta\} := \langle f : [R, U] \rangle X \langle F : [R, U] \rangle = f R U R' U' f' X F R U R' U' F'$$



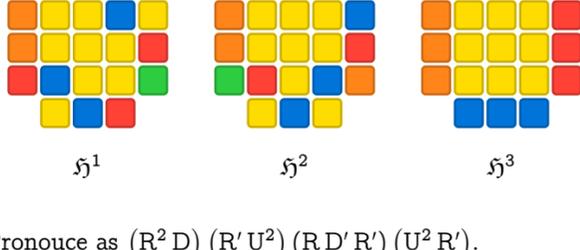
$$\{\delta X f\} := \langle F : [R, U] \rangle X \langle f : [R, U] \rangle = F R U R' U' F' X f R U R' U' f'$$



## Headlights

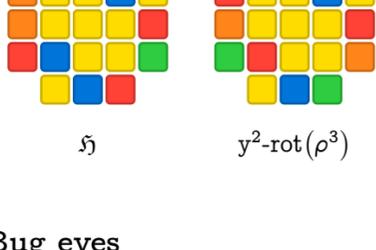
 is solved by  $\delta := \langle R : [(R : D), U^2] \rangle$ .

Alternatively,  is solved by  $\langle R^2 : [D', (R : U^2)] \rangle$ .



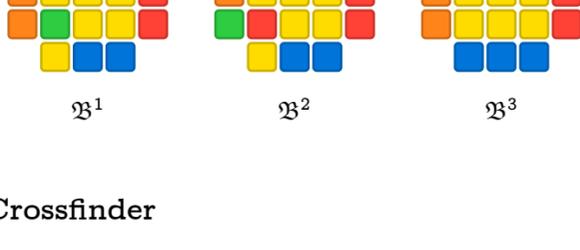
Pronounce as  $(R^2 D) (R' U^2) (R D' R') (U^2 R')$ .

Compare:

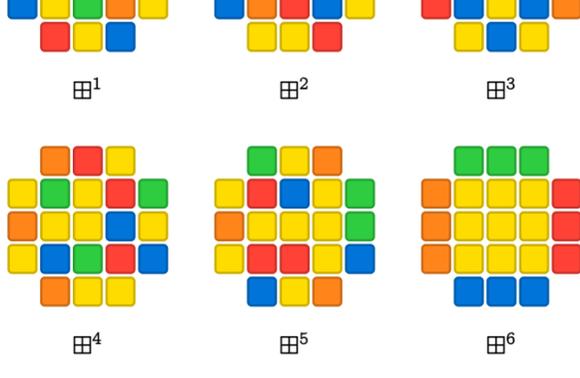


## Bug eyes

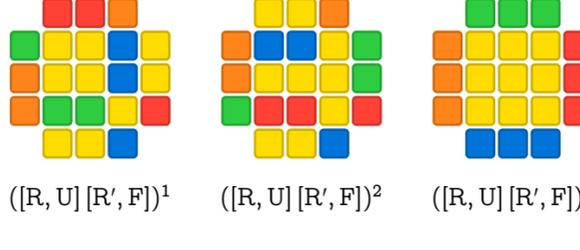
 is solved by  $\mathfrak{B} := \langle r U : R' \rangle \langle F : R \rangle = r U R' U' r' F R F'$ .



## Crossfinder



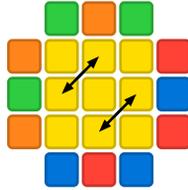
## Swish-swish



# Permute last layer

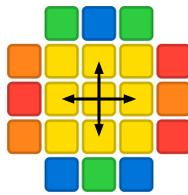
## Edges

### Z-permutation



$$(M^2 U) (M^2 U) (M U^2) (M^2 U^2) (M U^2)$$

### H-permutation



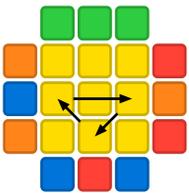
$$M^2 U M^2 U^2 M^2 U M^2$$

### U-permutation

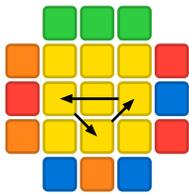
$$\mathfrak{U} := (R^2 U) (R U) (R' U')^2 (R' U R')$$

$$\mathfrak{U}' = (R U' R) (U R)^2 (U' R') (U' R'^2)$$

$$\text{x-refl}(\mathfrak{U}) = (L^2 U') (L' U') (L U)^2 (L U' L)$$



$\mathfrak{U}$



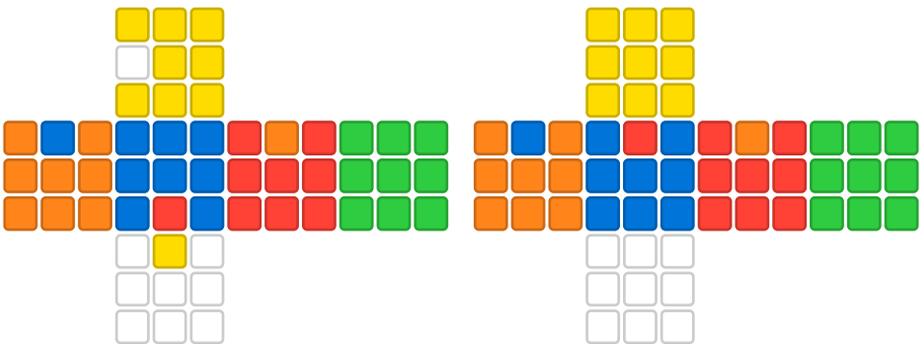
$\text{x-refl}(\mathfrak{U})$

Alternatively:

$$\mathfrak{U} = \langle R : \langle (R U)^2 : R' \rangle U \rangle$$

$$\text{x-refl}(\mathfrak{U}) = \mathfrak{U}' = \langle R : U' \langle (R U)^2 : R \rangle \rangle$$

The U-permutation can also be derived from this:



$U \langle M' : U^2 \rangle U$

$\langle F^2 : U \langle M' : U^2 \rangle U \rangle$

# Corners

## A-permutation

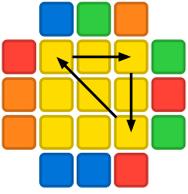
Clockwise, positioned bottom-left:

$$\mathfrak{A} := (R' F R') \langle B^2 R : F' \rangle R^2 = R' F R' B B R F' R' B' B' R R$$

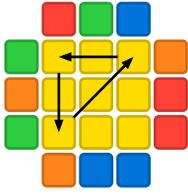
$$\mathfrak{A}' = R^2 \langle B^2 R : F' \rangle (R F' R)$$

Anticlockwise, positioned bottom-right:

$$\text{x-refl}(\mathfrak{A}) = (L F' L) \langle B^2 L' : F \rangle L^2 = L F' L B B L' F L B' B' L L$$



$\mathfrak{A}$



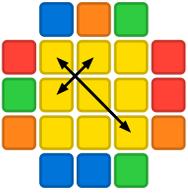
$\text{x-refl}(\mathfrak{A})$

## Y-permutation

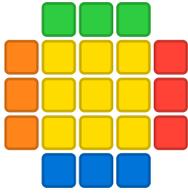
$$\eta := \langle F \langle R : U' \rangle : U' \rangle [R, U] [R', F]$$

$$= \eta' = [F, R'] [U, R] \langle F \langle R : U' \rangle : U \rangle$$

$$\text{x-refl}(\eta) = \langle F' \langle L' : U \rangle : U \rangle [L', U'] [L, F']$$

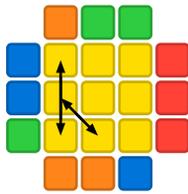


$\eta^1$

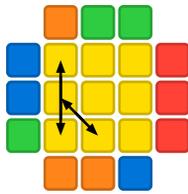


$\eta^2$

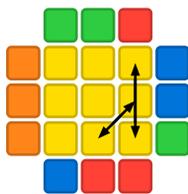
## J-permutation



$$L' U^2 L U L' U^2 R U' L U R'$$



$$\langle L' : U^2 \rangle U L' U^2 R U' L U R'$$

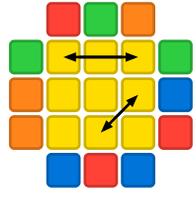


$$R U^2 R' U' R U^2 L' U R' U' L$$

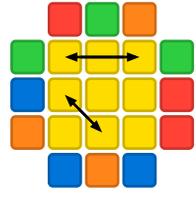
### R-permutation

$$\mathfrak{R} := (R' U^2 R U^2) R' F (R U R' U') R' F' R^2 U'$$

$$\text{x-refl}(\mathfrak{R}) = (L U^2 L' U^2) L F' (L' U' L U) L F L^2 U$$

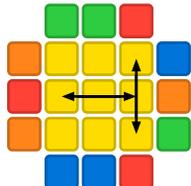


$\mathfrak{R}$



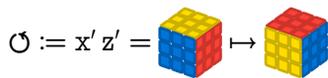
$\text{x-refl}(\mathfrak{R})$

### T-permutation

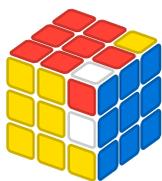


$$[R, U] (R' F R^2) \langle U' R' : U' \rangle R' F'$$

### F-permutation



$$\mathfrak{F} := [R, U] R U^2 \mathfrak{O} [R, U] \mathfrak{O} [R', U'] R^2$$



is solved by  $\mathfrak{F}$

### E-permutation

$$\Xi := (U' R U L') (U' R' U L) (U' R' U L') (U' R U L)$$

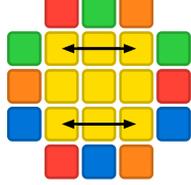
$$\text{x-refl}(\Xi) = (U L' U' R) (U L U' R') (U L U' R) (U L' U' R')$$

$$\text{z-refl}(\Xi) = (U R' U' L) (U R U' L') (U R U' L) (U R' U' L')$$

$$\text{z-rot}(\Xi) = (R' D R U) (R' D' R U) (R' D' R U) (R' D R U)$$



$\Xi$



$\langle x' : \Xi \rangle$

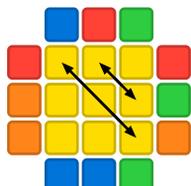


$\text{z-refl}(\Xi)$

### V-permutation

$$\mathfrak{V} := [R', U^2] \langle \langle L U' : R' \rangle : U \rangle$$

$$= R' U R U' U' L U' R' U L' U L U' R U L'$$

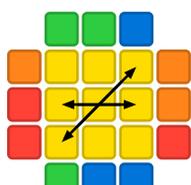


$\mathfrak{V}$

### N-permutation

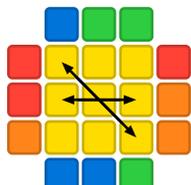
$$\mathfrak{N} := (R U R' U R U R' F') [R, U] (R' F) (R^2 U' R' U^2 R U' R')$$

$$= R U R' U R U R' F' R U R' U' R' F R R U' R' U U R U' R'$$

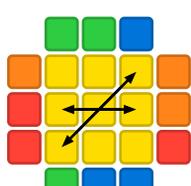


$\mathfrak{N}$

Alternatively:



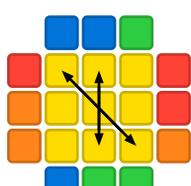
$\mathfrak{N}_*$



$\text{x-refl}(\mathfrak{N}_*)$

$$\mathfrak{N}_* := (R' U L' U^2 R U' L)^2 U$$

$$\text{x-refl}(\mathfrak{N}_*) = (L U' R U^2 L' U R')^2 U'$$



$$\text{z} \left( (D R' U) (R^2 D' R U') \right)^2 R z'$$

### G-permutation

$$\mathfrak{G} := \langle F' : U' \rangle \langle R^2 u R' U : R \rangle$$

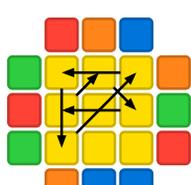
$$= F' U' F R R u R' U R U' R u' R' R'$$

$$\mathfrak{G}' = \langle R^2 u R' U : R' \rangle \langle F' : U \rangle$$

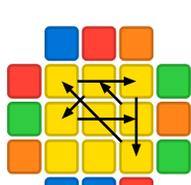
$$= R R u R' U R' U' R u' R' R' F' U F$$

$$\text{x-refl}(\mathfrak{G}) = \langle F : U \rangle \langle L^2 u' L U' : L' \rangle$$

$$= F U F' L L u' L U' L' U L' u L' L'$$



$\mathfrak{G}$



$\text{x-refl}(\mathfrak{G})$