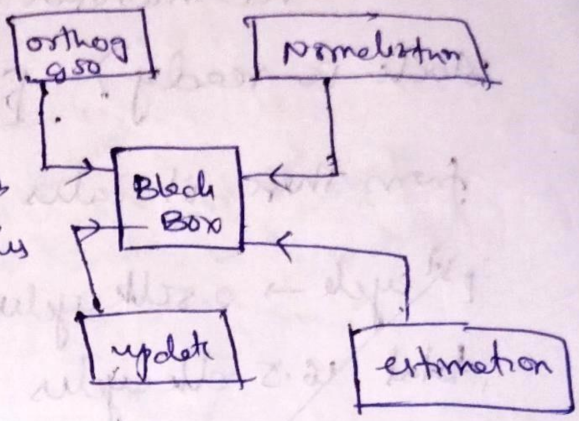
RTL – Orthogonalization, Normalization, Update, Estimation Blocks in Cordic.

Part: Normalization in 7D:



Block Box code – ready ✓

↓

doubly pipelining CORDIC (with vectoring & rotation) → vectoring – 16 clk cycles, rotation – 16 clk cycles

Total – 17 clk cycles.

overall overview:

1. first given input of two vectors in 7D

↓

$w_1 = \{w_{1.1}, w_{12}, w_{13}, w_{14}, w_{15}, w_{16}, w_{17}\}$

$w_2 = \{w_{21}, w_{22}, w_{23}, w_{24}, w_{25}, w_{26}, w_{27}\}$

2. Normalize w_1 to get $\underline{w_1}$ using 7D Normalization by select lines (mux & demux, as inputs vary)

   L-1 to 6 (rotations & vectoring) } using doubly pipelining
   L'-1 to 5 (rotations) }

   $17 \times 6 + 17 \times 5 = 17 \times 11 = 187$ clk cycles

3. Do GSO of $\underline{w_1}$ & w_2 using 7D GSO (add mux & demux, vary inputs in block box)

   L-1 to 6 (doubly), L'-1 to 5 (rotations) } doubly pipelining

   $17 \times 6 + 17 \times 5 = 187$ clk cycles.

4. Normalize $w_{2,new}$ to $\underline{w}_{2,new}$ (by same as above in ②)

   187 clk cycles

5. update block – $w_{2,new} = E[z(w^T z)^3] - 3w_k$

   after GSO & normalization, we send to update block to approximate the value to the correct value.

   (shld work more on it) memory block

6. Estimation block – after GSO, normalization, update block we estimate the value: ($S = w^T z$) – Thus is the final value / end.

In vectoring: Make test bench such that
at posedge of clock → ~~reset becomes~~ input starts. (x) done ✓

when vec-microRot-out-start begins (output of 1st vectoring block is ready) : [0.5 clk cycle only it takes]

from there it takes 16 clk cycles to compute final output.

1st cycle → 0.5 clk cycles
total 16.5 clk cycles } so the next 15 stages take 16 clock cycles

1st stage — 0.5   4 — 1
2nd — 1   5 — 1
3 — 1   ...

1st stage — 0.5 clk
2 – 15 stages — 1 clk (14)
16 stage — 1 clk
} total 16.5

1 clk to output scale.

when reset delay is made p4.999 everything solved.

if this happens we finish vectoring in 15.5 clk cycles.

can we not run clk to output scale like input upscale?

Total 16.5 (16 clk cycles after vec-micro Rot-out-start becomes 1.

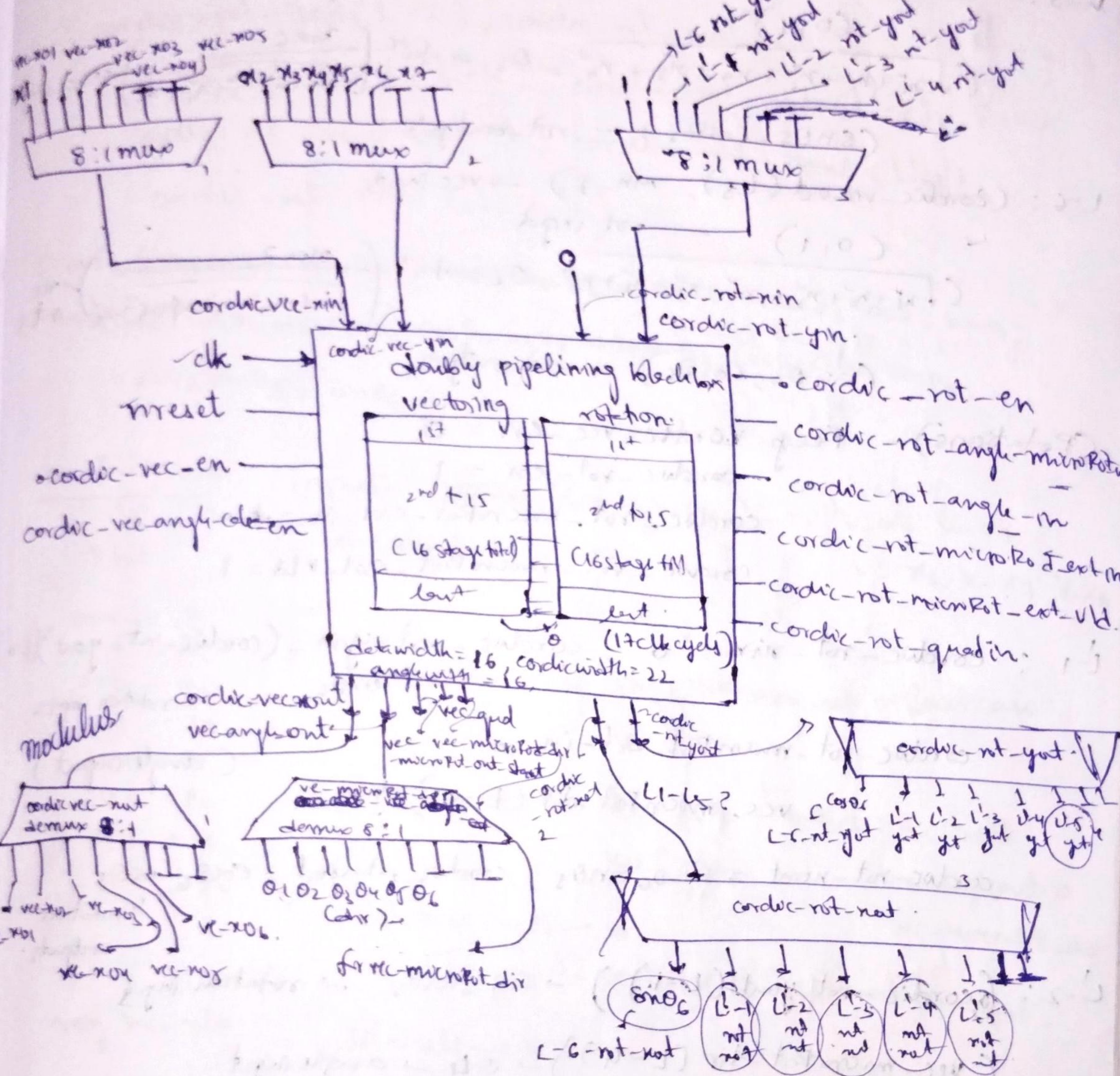
In rotation: even rotation takes 16.5 clk cycles similar to vectoring.
1st of the angle comes from extend.

In doubly pipelining: totally to get output it takes 17.5 clk cycles.
vectoring output comes in 16.5 clk cycles.
rotation starts after 1 clk cycles
in testbench — giving 0.5 clk cycle delay b/w vec-enable & rot-enable is making unnecessary outputs to go away but
cordic-rot-opvld is being 1 (1 clk cycle before only)
there, the two always checks the → $\frac{1}{2}+\frac{1}{2}=1$ clk cycle.
Something goes wrong with → rot_op vld → is being 1 – before 1 clk cycle only: # some error in code itself.
This thing rectify in doubly pipelining code.
Corrected this problem ✓ → by accounting latency
0.001 ns delay added.

Normalization of 7D using 2D doubly pipelining as a blackbox:

Inputs: xin-1, xin-2, xin-3, xin-4, xin-5, xin-6, xin-7 (7D vector)

final output: L'-5 yout, L'-5 xout, L'-4 xout, L'-3 xout, L'-2 xout, L'-1 xout, L-6 xout.



Doubly pipelining;

L-1: cordic-vec-xin = xin-1, cordic-vec-yin = xin-2

cordic-rot-xin = 0 , cordic-rot-yin = 1

cordic_vec-xout = $\sqrt{xin\text{-}1^2 + xin\text{-}2^2}$, vec_angle-out = $\theta_1 = \tan^{-1}\left(\frac{xin2}{xin1}\right)$

cordic-rot-xout = $\sin\theta_1$, cordic-rot-yout = $\cos\theta_1$

$\begin{pmatrix} x_0 \\ y_0 \end{pmatrix} = \begin{pmatrix} c & s \\ -s & c \end{pmatrix}\begin{pmatrix} x_i \\ y_i \end{pmatrix}$, $x_0 = s x_1$, $y_0 = c y_i$

L-2: (cordic_vec_xout (L1), xin-3) → vec inputs

(0, 1) → rot inputs

$\left(\sqrt{xin\text{-}1^2 + xin\text{-}2^2 + xin\text{-}3^2},\ \theta_2 = \tan^{-1}\left(\frac{xin_3}{\sqrt{x_1^2+x_2^2}}\right)\right)$ → vec outputs

$(\sin\theta_2, \cos\theta_2)$ → rot outputs

L-3: (cordic-vec-xout (L2), xin-4) → vec inputs

(0, 1) → rot inputs

$\left(\sqrt{xin\text{-}1^2 + xin\text{-}2^2 + xin\text{-}3^2 + xin\text{-}4^2},\ \theta_3 = \tan^{-1}\left(\frac{xin4}{\sqrt{x_1^2+x_2^2+x_3^2}}\right)\right)$ → vec outputs

$(\sin\theta_3, \cos\theta_3)$ → rot outputs

L-4 : (cordic-vec-out (L3), xin-5) → vec inputs

(0, 1) → rot-inputs

$\left(\sqrt{x_1^2+x_2^2+x_3^2+x_4^2+x_5^2},\ \theta_4 = \tan^{-1}\left(\frac{xin5}{\sqrt{x_1^2+x_2^2+x_3^2+x_4^2}}\right)\right)$ → vec-outputs

$(\sin\theta_4, \cos\theta_4)$ → rot-outputs.

L-5: (cordic-vec-out (L4), xin-6) → vec inputs

(0, 1)

$\left(\sqrt{x_1^2+x_2^2+x_3^2+x_4^2+x_5^2+x_6^2},\ \theta_5 = \tan^{-1}\left(\frac{xin6}{\sqrt{x_1^2+x_2^2+x_3^2+x_4^2+x_5^2}}\right)\right)$ → vec outputs

$(\sin\theta_5, \cos\theta_5)$ → rot-outputs.

L-6 : (cordic-vec-out (L5), xin-7) - vec inputs

(0, 1) → rot inputs

$\left(\sqrt{x_1^2+x_2^2+x_3^2+x_4^2+x_5^2+x_6^2+x_7^2},\ \theta_6 = \tan^{-1}\left(\frac{xin7}{\sqrt{x_1^2+x_2^2+x_3^2+x_4^2+x_5^2+x_6^2}}\right)\right)$ → vec outputs

$(\sin\theta_6, \cos\theta_6)$ → rot outputs.

(Rotations) - Keep cordic-vec-en = 0

cordic-rot-en = 1

cordic-rot-microRot-ext-in = ✓

cordic-rot-microRot-ext-vld = 1

L'-1 : cordic-rot-xin = 0, cordic-rot-yin = (cordic-rot-yout)(L-6) → rotation inputs

"$\cos\theta_6$"

cordic-rot-microRot-ext-in = vec-microRot-dir (L-5) } θ_5 dir (angle input).

cordic-rot-xout = $\cos\theta_6 \sin\theta_5$, cordic-rot-yout = $\cos\theta_6 \cos\theta_5$ → rotation outputs.

L'-2: (0, cordic-rot-yout (L'-1)) → $\cos\theta_6 \cos\theta_5$ → rotation input

(vec-microRot-dir (L-4)) → θ_4 → angle input

$(\cos\theta_6 \cos\theta_5 \sin\theta_4,\ \cos\theta_6 \cos\theta_5 \cos\theta_4)$ → rotation output

L'-3: (0, cordic-rot-yout (L'-2)) → $\cos\theta_6 \cos\theta_5 \cos\theta_4$ → rotation input

(vec-microRot-dir (L-3)) → θ_3 → angle input.

$(\cos\theta_6 \cos\theta_5 \cos\theta_4 \sin\theta_3,\ \cos\theta_6 \cos\theta_5 \cos\theta_4 \cos\theta_3)$ → rotation output

L'-4: (0, cordic-rot-yout (L'-3)) → $\cos\theta_6 \cos\theta_5 \cos\theta_4 \cos\theta_3$ → rotation input

(vec-microRot-dir (L-2)) → θ_2 → angle input

$(\cos\theta_6 \cos\theta_5 \cos\theta_4 \cos\theta_3 \sin\theta_2,\ \cos\theta_6 \cos\theta_5 \cos\theta_4 \cos\theta_3 \cos\theta_2)$

5: (0, cordic-rot-yout (L'-4)) – $\cos\theta_6 \cos\theta_5 \cos\theta_4 \cos\theta_3 \cos\theta_2$ – rotation input

(vec-microRot-dir (L-1)) – θ_1-angle input

($\cos\theta_6 \cos\theta_5 \cos\theta_4 \cos\theta_3 \cos\theta_2 \sin\theta_1$, $\cos\theta_6 \cos\theta_5 \cos\theta_4 \cos\theta_3 \cos\theta_2 \cos\theta_1$)

Final normalized vector for (x_{in-1}, x_{in-2}, x_{in-3}, x_{in-4}, x_{in-5}, x_{in-6}, x_{in-7})

= (cordic-rot-yout (L'-5), cordic-rot-xout (L'-5),
cordic-rot-xout (L'-4), cordic-rot-xout (L'-3),
cordic-rot-xout (L'-2), cordic-rot-xout (L'-1),
cordic-rot-xout (L'-6))

($\cos\theta_6 \cos\theta_5 \cos\theta_4 \cos\theta_3 \cos\theta_2 \cos\theta_1$, $\cos\theta_6 \cos\theta_5 \cos\theta_4 \cos\theta_3 \cos\theta_2 \sin\theta_1$,
$\cos\theta_6 \cos\theta_5 \cos\theta_4 \cos\theta_3 \sin\theta_2$, $\cos\theta_6 \cos\theta_5 \cos\theta_4 \sin\theta_3$, $\cos\theta_6 \cos\theta_5 \sin\theta_3$,
$\cos\theta_6 \sin\theta_5$, $\sin\theta_6$)

for 8:1 mux: inputs: V_x1, V_x2, V_x3, V_x4, V_x5,
V_x6, V_x7, V_x8
sel [2:0] — 16 bit

3 bit

000 → x1
001 → x2
010 → x3
011 → x4
100 → x5
101 → x6
110 → x7
111 → x8

done – if in ~~...~~ of in last case
in done.

vectoring input – vec-xin   outputs: vec-xout
vec-yin   vec-angleout-x0
vec-microRot-dir

Rotation inputs – 0
– Rot-yin   Rot-xout   Rot-yout

reg vec-xin   sel → sel1 – vec-xin
sel2 – vec-yin

Intermediates for mux & demux:

→ Vec-x01 ... Vec-x06

→ ~~...~~ vec-microRot-01 .. vec-microRot-02

→ L6-rot-xout, L'1 rot-xout L'2-rot-xout – L'5

→ L6-rot-yout, L'2-rot-yout ... L'5

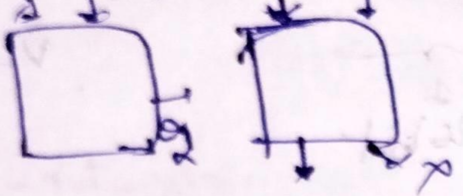
Total clk cycles – ~~...~~ 16×5 + 17×1 + 16×5 = $\underline{177}$

gso : $u_1 = v_1 \rightarrow$ ~~cos~~ ~~v~~ ~~v~~ v_3 V_{xa-1} V_{xa-2} V_{xa-3} V_{xa-4} V_{xa-5} V_{xa-6} V_{xa-7}.

$u_2 = v_2 -$ (scalarproduct) $\cos\theta$

scalarproduct $\rightarrow$

V_{xa-1} V_{xa-2} V_{xb-1} V_{xb-2}



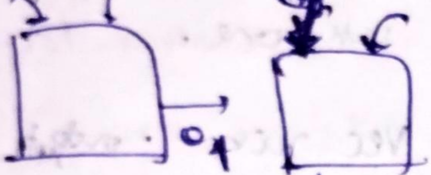
$$\begin{pmatrix} x_o \\ y_o \end{pmatrix} = \begin{pmatrix} c & +s \\ -s & c \end{pmatrix} \begin{pmatrix} x_i \\ y_i \end{pmatrix}$$

$x_o = cx_i + sy_i$

$y_o = -sx_i + cy_i$

$\sqrt{V_{xa1}^2 + V_{xa2}^2}$ V_{xa-3} $V_{xb-1}\cos\theta_1 + V_{xb-2}\sin\theta_1$

V_{xb-3}



θ_1

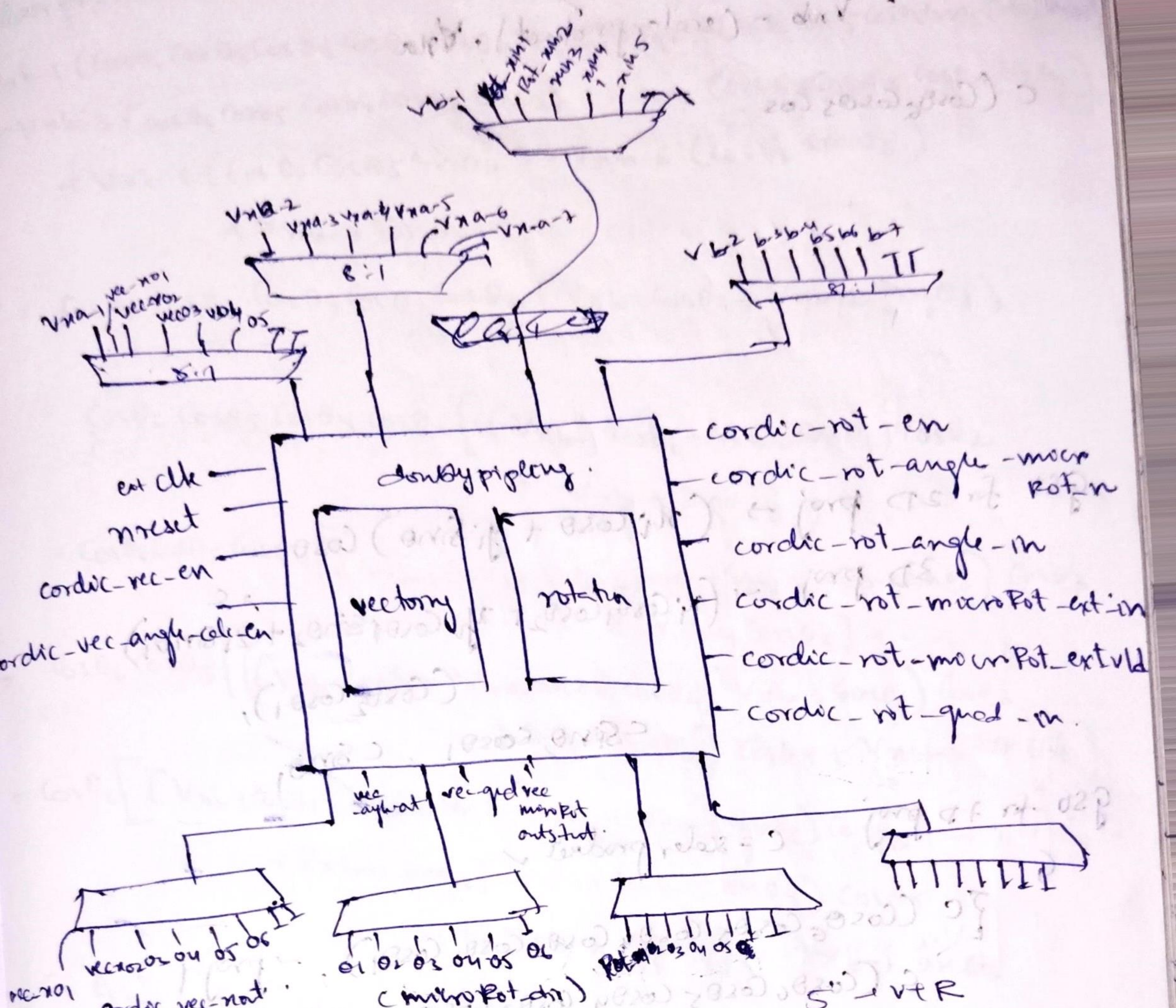
$(V_{xb-1}\cos\theta_1 + V_{xb-2}\sin\theta_1)\cos\theta_2 + (V_{xb-3})\sin\theta_2$

proj3D $V_{xb-1}\cos\theta_1\cos\theta_2 + V_{xb-2}\cos\theta_1\sin\theta_2 + (V_{xb-3})\sin\theta_1$:

$\cos\theta_2\cos\theta_1$ $\sin\theta_2\cos\theta_1$ $\sin\theta_1$ $\leftarrow$ for 3D.

V_{xb-3}.

$u_2 = v_2 -$ (proj) $\cos\theta$



S → V+R

6th → V θ6 2θ6

7th → Rot

8th →

Scalar product of 7D:

$V_{xa} = V_{xa\_1}, V_{xa\_2}, V_{xa\_3}, V_{xa\_4}, V_{xa\_5}, V_{xa\_6}, V_{xa\_7}$

normalized $= \cos\theta_6 \cos\theta_5 \cos\theta_4 \cos\theta_3 \cos\theta_2 \cos\theta_1,\ \cos\theta_6 \cos\theta_5 \cos\theta_4 \cos\theta_3 \cos\theta_2 \sin\theta_1,$
$\cos\theta_6 \cos\theta_5 \cos\theta_4 \cos\theta_3 \sin\theta_2,\ \cos\theta_6 \cos\theta_5 \cos\theta_4 \sin\theta_3,$
$\cos\theta_6 \cos\theta_5 \sin\theta_4,\ \cos\theta_6 \sin\theta_5,\ \sin\theta_6$

scalar product $= V_{xb} \cdot V_{xa}$

$(c) = V_{xb-1} \cdot V_{xa-1} + V_{xb-2} \cdot V_{xa-2} + V_{xb-3} \cdot V_{xa-3} +$
$V_{xb-4} \cdot V_{xa-4} + V_{xb-5} V_{xa-5} + V_{xb-6} V_{xa-6} + V_{xb-7} V_{xa-7}$

$= V_{xb-1}(\cos\theta_6 \cos\theta_5 \cos\theta_4 \cos\theta_3 \cos\theta_2 \cos\theta_1)$
$+ V_{xb-2}(\cos\theta_6 \cos\theta_5 \cos\theta_4 \cos\theta_3 \cos\theta_2 \sin\theta_1)$
$+ V_{xb-3}(\cos\theta_6 \cos\theta_5 \cos\theta_4 \cos\theta_3 \sin\theta_2)$
$+ V_{xb-4}(\cos\theta_6 \cos\theta_5 \cos\theta_4 \sin\theta_3)$
$+ V_{xb-5}(\cos\theta_6 \cos\theta_5 \sin\theta_4) + V_{xb-6}(\cos\theta_6 \sin\theta_5) + V_{xb-7}$

GSO fr 2D proj → $(x_i \cos\theta + y_i \sin\theta)\cos\theta$

3D proj → $(x_i \cos\theta_1 \cos\theta_2 + y_i \cos\theta_1 \sin\theta_2 + z_i \sin\theta_1)$, c

$(\cos\theta_2 \cos\theta_1)$,

$c \sin\theta_2 \cos\theta_1$, $c \sin\theta_1$

GSO fr 7D proj   c = scaler product ✓

G.

$\{ c(\cos\theta_6 \cos\theta_5 \cos\theta_4 \cos\theta_3 \cos\theta_2 \cos\theta_1)$, → proj 1

$c(\cos\theta_6 \cos\theta_5 \cos\theta_4 \cos\theta_3 \cos\theta_2 \sin\theta_1)$, → proj 2

$c(\cos\theta_6 \cos\theta_5 \cos\theta_4 \cos\theta_3 \sin\theta_2)$, → proj 3

$c(\cos\theta_6 \cos\theta_5 \cos\theta_4 \sin\theta_3)$, → proj 4

$c(\cos\theta_6 \cos\theta_5 \sin\theta_4)$, → proj 5

$c(\cos\theta_6 \sin\theta_5)$, $c(\sin\theta_6) \}$
→ proj 6   → proj 7

GSO nont = $\{ V_{xb-1}$ − proj 1, V_{xb-2} − proj 2

V_{xb-3} − proj 3, V_{xb-4} − proj 4,

V_{xb-5} − proj 5, V_{xb-6} − proj 6,

V_{xb-7} − proj 7 $\}$.

calar product:

$V_{xb-1}\left(\cos\theta_6\cos\theta_5\cos\theta_4\cos\theta_3\cos\theta_2\cos\theta_1\right) + V_{xb-2}\left(\cos\theta_6\cos\theta_5\cos\theta_4\cos\theta_3\cos\theta_2\sin\theta_1\right)$
$+ V_{xb-3}\left(\cos\theta_6\cos\theta_5\cos\theta_4\cos\theta_3\sin\theta_2\right) + V_{xb-4}\left(\cos\theta_6\cos\theta_5\cos\theta_4\sin\theta_3\right)$
$+ V_{xb-5}\left(\cos\theta_6\cos\theta_5\sin\theta_4\right) + V_{xb-6}\left(\cos\theta_6\sin\theta_5\right)$
$+ V_{xb-7}\sin\theta_6$

$$C = \cos\theta_6\cos\theta_5\cos\theta_4\cos\theta_3\cos\theta_2\left(V_{xb-1}\cos\theta_1 + V_{xb-2}\sin\theta_1\right) + \dots$$

$$= \cos\theta_6\cos\theta_5\cos\theta_4\cos\theta_3\left[\left(V_{xb-1}\cos\theta_1 + V_{xb-2}\sin\theta_1\right)\cos\theta_2 + V_{xb-3}\sin\theta_2\right] + \dots$$

$$= \cos\theta_6\cos\theta_5\cos\theta_4\left[\left(\left(V_{xb-1}\cos\theta_1 + V_{xb-2}\sin\theta_1\right)\cos\theta_2 + V_{xb-3}\sin\theta_2\right)\cos\theta_3 + V_{xb-4}\sin\theta_3\right] + \dots$$

$$= \cos\theta_6\cos\theta_5\left[\left(\left(\left(V_{xb-1}\cos\theta_1 + V_{xb-2}\sin\theta_1\right)\cos\theta_2 + V_{xb-3}\sin\theta_2\right)\cos\theta_3 + V_{xb-4}\sin\theta_3\right)\cos\theta_4 + V_{xb-5}\sin\theta_4\right] + \dots$$

$$= \cos\theta_6\left[\left(V_{xb-1}\cos\theta_1 + V_{xb-2}\sin\theta_1\cos\theta_2 + V_{xb-3}\sin\theta_3\right)\cos\theta_3 + V_{xb-4}\sin\theta_3\right]\cos\theta_4 + V_{xb-5}\sin\theta_4\big)\cos\theta_5 + V_{xb-6}\sin\theta_5\big] + V_{xb-7}\sin\theta_6$$

$$= Rot_x^6\left(Rot_x^5\left(Rot_x^4\left(Rot_x^3\left[Rot_x^2\left(Rot_x^1\left(V_{xb-1}, V_{xb-2}, \theta_1\right), V_{xb-3}, \theta_2\right), \left(V_{xb-4}, \theta_3\right), V_{xb-5}, \theta_4\right), V_{xb-6}, \theta_5\right), V_{xb-7}, \theta_6\right)$$

$In\ 2D: = (V_x \cos\theta_1 + V_y \sin\theta_1)\cos\theta_1$ $\quad V_x, V_y$

(1) $= V_x \cos^2\theta_1 + V_y \sin\theta_1 \cos\theta_1$ $\quad \cos 2\theta = 2\cos^2\theta - 1$

$= \frac{1}{2}\left[V_x(\cos 2\theta + 1) + V_y \sin 2\theta\right]$

$= \frac{1}{2}\left[V_x + V_x \cos 2\theta + V_y \sin 2\theta\right]$

$\rightarrow V_x - \frac{1}{2}\left[V_x + V_x \cos 2\theta + V_y \sin 2\theta\right]$

$= \frac{1}{2}\left[V_x - (V_x \cos 2\theta + V_y \sin 2\theta)\right] = \frac{1}{2}\left[V_x - Rot_x(V_x, V_y, 2\theta)\right]$

$Sin\ 2D: (V_x \cos\theta_1 + V_y \sin\theta_1)\sin\theta_1$

(2) $= V_x \cos\theta_1 \sin\theta_1 + V_y \sin^2\theta_1$ $\quad \cos 2\theta = 1 - 2\sin^2\theta$

$2\sin^2\theta = 1 - \cos 2\theta$

$= \frac{1}{2}\left[V_x \sin 2\theta + V_y(1 - \cos 2\theta)\right]$

$= V_y - \frac{1}{2}\left[V_x \sin 2\theta - V_y \cos 2\theta + V_y\right]$

$= \frac{1}{2}\left[V_y - (V_x \sin 2\theta - V_y \cos 2\theta)\right]$

$= \frac{1}{2}\left[V_y - Rot_y(V_x, V_y, 2\theta)\right]$

$GSO: \frac{1}{2}\begin{bmatrix} V_x - Rot_x(V_x, V_y, 2\theta) \\ V_y - Rot_y(V_x, V_y, 2\theta) \end{bmatrix}$

$\cos\theta_2 \cos\theta_1$

In 3D: $(V_x \cos\theta_2 \cos\theta_1 + V_y \cos\theta_2 \sin\theta_1 + V_z \sin\theta_2) \cos\theta_2 \cos\theta_1$

$(V_x \cos^2\theta_2 \cos\theta_1 + V_y \cos^2\theta_2 \sin\theta_1 + V_z \sin\theta_2 \cos\theta_2) \cos\theta_1$

$\frac{1}{2} [2\cos^2\theta_2 (V_x \cos\theta_1 + V_y \sin\theta_1) + 2V_z \sin\theta_2 \cos\theta_2] \cos\theta_1$

$= \frac{1}{2} [(V_x \cos\theta_1 + V_y \sin\theta_1)(\cos 2\theta_2 + 1) + V_z (\sin 2\theta_2)] \cos\theta_1$

$= \frac{1}{2} [Rot'_x(V_x, V_y, \theta_1) \cos 2\theta_2 + V_z \sin 2\theta_2 + Rot_x(V_x, V_y, \theta_1)] \cos\theta_1$

$V_x = \frac{1}{2} [Rot^2_x [(Rot'_x(V_x, V_y, \theta_1), V_z, 2\theta_2] + Rot'_x(V_x, V_y, \theta_1)] \cos\theta_1$

$= (V_x \cos\theta_2 \cos\theta_1 + V_y \cos\theta_2 \sin\theta_1 + V_z \sin\theta_2) \sin\theta_2$ $\quad 2\sin^2\theta = 1 - \cos 2\theta$

$= V_x \cos\theta_1 \sin\theta_2 \cos\theta_2 + V_y \sin\theta_2 \cos\theta_2 \sin\theta_1 + V_z \sin^2\theta_2$

$= \frac{1}{2} [\sin 2\theta (Rot_x(V_x, V_y, \theta_1)) + V_z (1 - \cos 2\theta)]$

$\frac{1}{2} [V_z - Rot^2_y (Rot'_x(V_x, V_y, \theta_1), V_z, 2\theta_2)]$ — final.

$= V_x - V_x \cos^2\theta_1 \cos^2\theta_2 + V_y \cos^2\theta_2 \cos\theta_1 \sin\theta_1 + V_z \cos\theta_1 \cos\theta_2 \sin\theta_2$

final $= V_x - V_x \cos^2\theta_2 (1 - \sin^2\theta_1)$

$= V_x \sin^2\theta_2 + V_x \cos^2\theta_2 \sin^2\theta_1 + V_y \cos^2\theta_2 \sin\theta_1 \cos\theta_1 + V_z \cos\theta_1 \cos\theta_2 \sin\theta_2$

$= V_x \sin^2\theta_2 + \cos^2\theta_2 (V_x \sin^2\theta_1 + V_y \sin\theta_1 \cos\theta_1) + V_z \cos\theta_1 \cos\theta_2 \sin\theta_2$

$= V_x \sin^2\theta_2 + \frac{1}{2} \cos^2\theta_2 (V_x(1 - \cos 2\theta_1) + V_y \sin 2\theta_1) + V_z \cos\theta_1 \cos\theta_2 \sin\theta_2$

$= V_x \sin^2\theta_1 + \frac{1}{2} \cos^2\theta_2 (V_x - Rot_y(V_x, V_y, 2\theta_1$

understand it later.

$\omega_{11} = \frac{1}{2}\left(Rot_y\left(0, \left(Rot_x^{3D,l_1} - Rot_y^{3D,l_2}\right), \theta_1\right)\right)$

$Rot_x^{3D,l_1} = Rot_x(V_x, V_y, \theta_1) \to V_x\cos\theta_1 + V_y\sin\theta_1$

$Rot_y^{3D,l_2} = Rot_y(V_z, Rot_x^{3D,l_1}, 2\theta_2)$

$\left(Rot_x^{3D l_1} - V_z \sin 2\theta_2 + Rot_x^{3D l_1}(\cos 2\theta_2)\right)\cos\theta_1$

$\frac{1}{2} Rot_x^{3D l_1}(1+\cos 2\theta_2) - \frac{1}{2} V_z \sin 2\theta_2$

$Rot_x^{3D l_1} \cos^2\theta_2 + V_z \cdot \sin\theta_2\cos\theta_2$

$\left((V_x\cos\theta_1 + V_y\sin\theta_1)\cos^2\theta_2 + V_z\sin\theta_2\cos\theta_2\right)\cos\theta_1$

$(V_x\cos\theta_1 + V_y\sin\theta_1)\cos\theta_2 + V_z\sin\theta_2)\cos\theta_1\cos\theta_2$

$(V_x\cos\theta_2\cos\theta_1 + V_y\cos\theta_2\sin\theta_1 + V_z\sin\theta_2)\cos\theta_2\cos\theta_1$

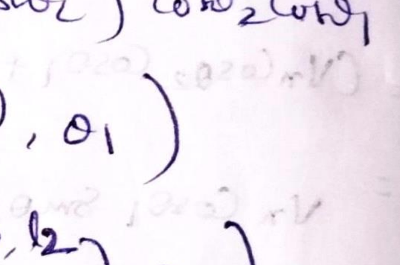
$\to \cancel{R}x = \frac{1}{2}\left[Rot_y\left(0, Rot_x^{3D,l_1} - Rot_y^{3D,l_2}\right), \theta_1\right)$

$\cancel{R}y = \frac{1}{2}\left(Rot_x\left(0, Rot_x^{3D,l_1} - Rot_y^{3D,l_2}\right), \theta_1\right)$

$Rz = \frac{1}{2}\left[V_z + Rot_x^{3D,l_2}\right]$ $\quad l_2 \to 2\theta_2$

$= \frac{1}{2}\left[V_z + \left(Rot_y(V_z, Rot_x^{3D,l_1}, 2\theta_2)\right)\right)$

$\to$ 3D:

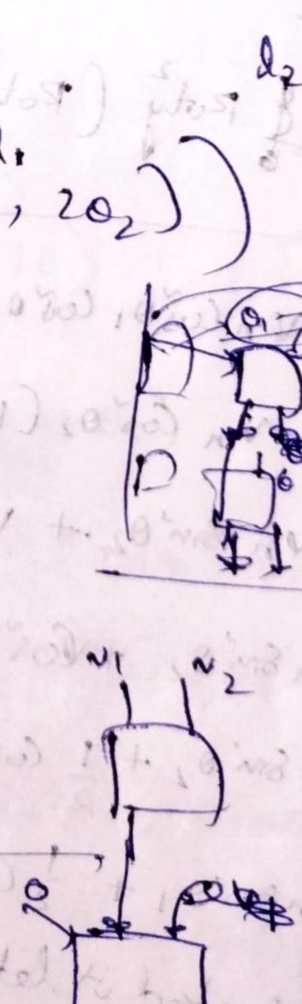


~~Rot~~

$V_1(2\cos^2\theta - 1) + V_2(2\sin\theta\cos\theta)$

$\frac{1}{2}\{V_1 + V_1\cos^2\theta + V_2\sin\theta\cos\theta)\}$

$\frac{1}{2}\left[-V_1 + (\underbrace{V_1\cos\theta + V_2\sin\theta}) \cos\theta\right]$



Q80. 7D:

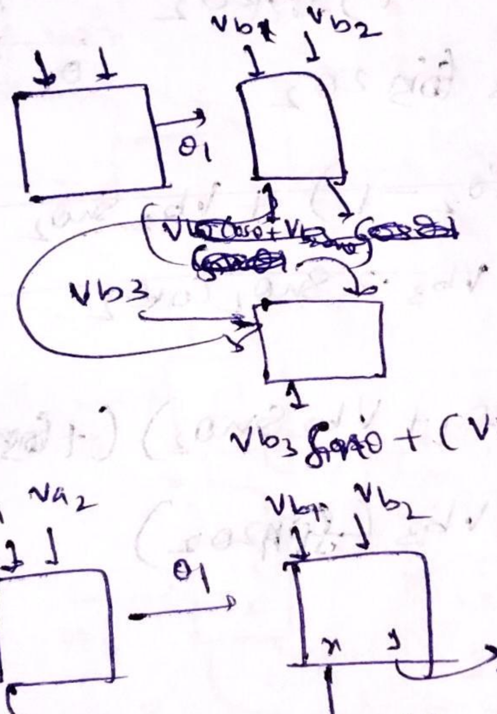
$$\begin{bmatrix} out\_1 \\ out\_2 \\ out\_3 \\ out\_4 \\ out\_5 \\ out\_6 \\ out\_7 \end{bmatrix} = \begin{bmatrix} V_{b,1} - \frac{1}{2} R_y^{7D, l'_5} \\ V_{b,2} - \frac{1}{2} R_x^{7D, l'_5} \\ V_{b,3} - \frac{1}{2} R_x^{7D, l'_4} \\ V_{b,4} - \frac{1}{2} R_x^{7D, l'_3} \\ V_{b,5} - \frac{1}{2} R_x^{7D, l'_2} \\ V_{b,6} - \frac{1}{2} R_x^{7D, l'_1} \\ \frac{1}{2} \left(V_{b,7} - Rot_x^{7D, l_6} \right) \end{bmatrix}$$

$$Rot_x^{7D; l_6} = Rot_x(V_{b,7}, Rot_x^{7D, l_5}, 2\theta_6)$$

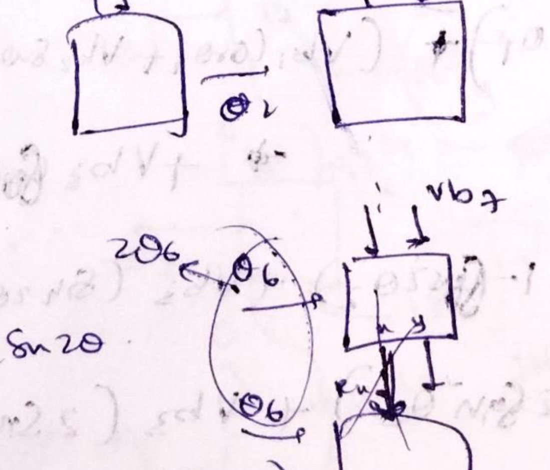
$$= \cancel{Rot(V_{b,7}}$$

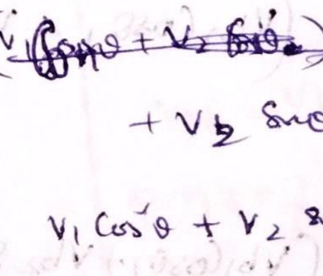
$$Rot_x^{7D l_5} = Rot_x(V_{b,6}, Rot_x^{7D l_4}, \theta_5) \ldots$$

(7 rotations) – $\theta_1, \theta_2, \theta_3, \theta_4, \theta_5, \theta_6, \theta_6$



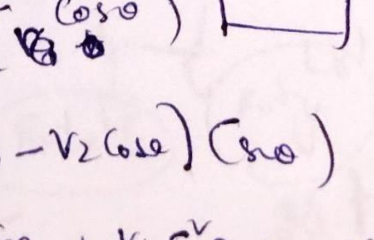
$V_{b3} \sin\theta + (V_{b1}\cos\theta + V_{b2}\sin\theta)\sin\theta$





$\cancel{(V_1 \sin\theta + V_2 \sin\theta)\sin\theta}$

$+ V_2 \sin\theta$



$V_1 \cos^2\theta + V_2 \sin\theta\cos\theta$

$+ V_2 \sin\theta$

$V_1 \cos^2 2\theta + V_2 \sin 2\theta$

$(V_1\cos\theta + V_2\sin\theta)\cos\theta + V_2\sin\theta$

$(V_1 \cos\theta + V_2 \sin\theta)(\cos\theta)$

$\cancel{V_1 \sin 2\theta}$

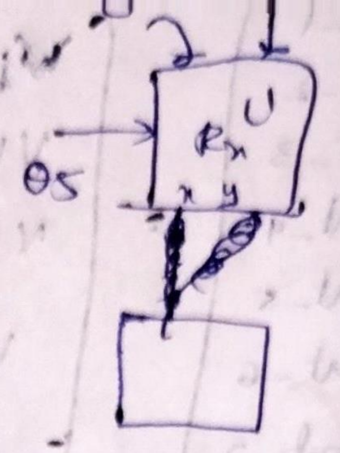
$+ (V_1 \sin\theta - V_2\cos\theta)(\sin\theta)$

$\frac{1}{2} V_1 (\cos 2\theta + 1) + \frac{V_2}{2}\sin 2\theta + V_2 \sin\varphi$

$V_1\cos^2\theta + V_2 \cos\theta\sin\theta + V_1 \sin^2\theta + - V_2 \sin\theta\cos\theta - V_1$

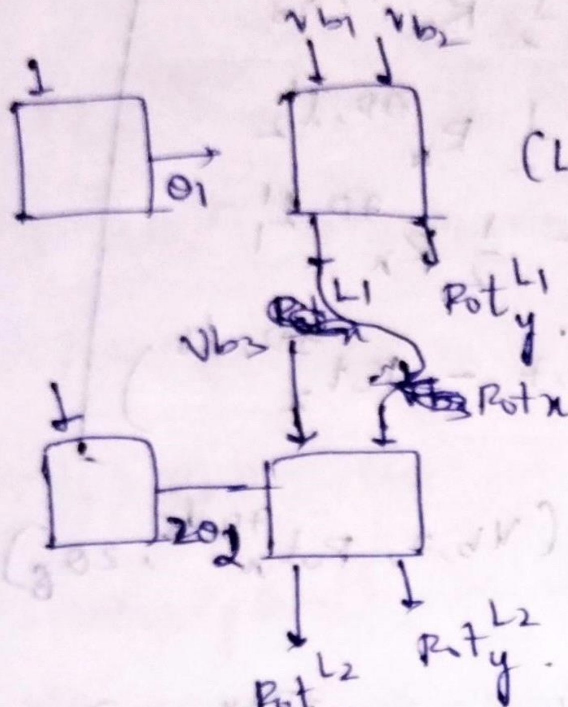
$R_x^{2D, l_i} =$

$\left(Rot_x^{2D, l_5} - Rot_y^{2D, l_6}\right),$



3D:

Vb1 Vb2
Vb3



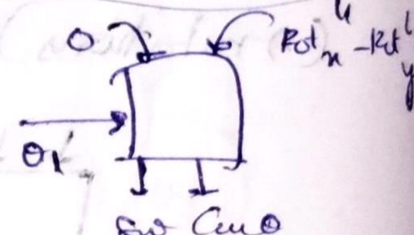
$\cos\theta_2 \cos\theta_1$

$\cos\theta_2 \sin\theta_1$

$\sin\theta_2$

$Rot_x^{L_1} = Vb_1 \cos\theta_1 + Vb_2 \sin\theta_1$

$Rot_y^{L_1} = Vb_1 \sin\theta_1 - Vb_2 \cos\theta_1$



$Rot_x^{L_2} = (Vb_1 \cos\theta_1 + Vb_2 \sin\theta_1) \sin 2\theta_2 + Vb_3 \sin 2\theta_2$

$= \cancel{Vb_1 \cos\theta_1 (2\cos^2\theta_2 - 1) + Vb_2 \sin\theta_2 (2\cos^2\theta_2 - 1)}$
$\cancel{+ Vb_3 \cdot 2 \sin\theta_2 \cos\theta_2}$

$Rot_y^{L_2} = (Vb_1 \cos\theta_1 + Vb_2 \sin\theta_2)(+\cos 2\theta_2) + Vb_3 (\sin 2\theta_2)$

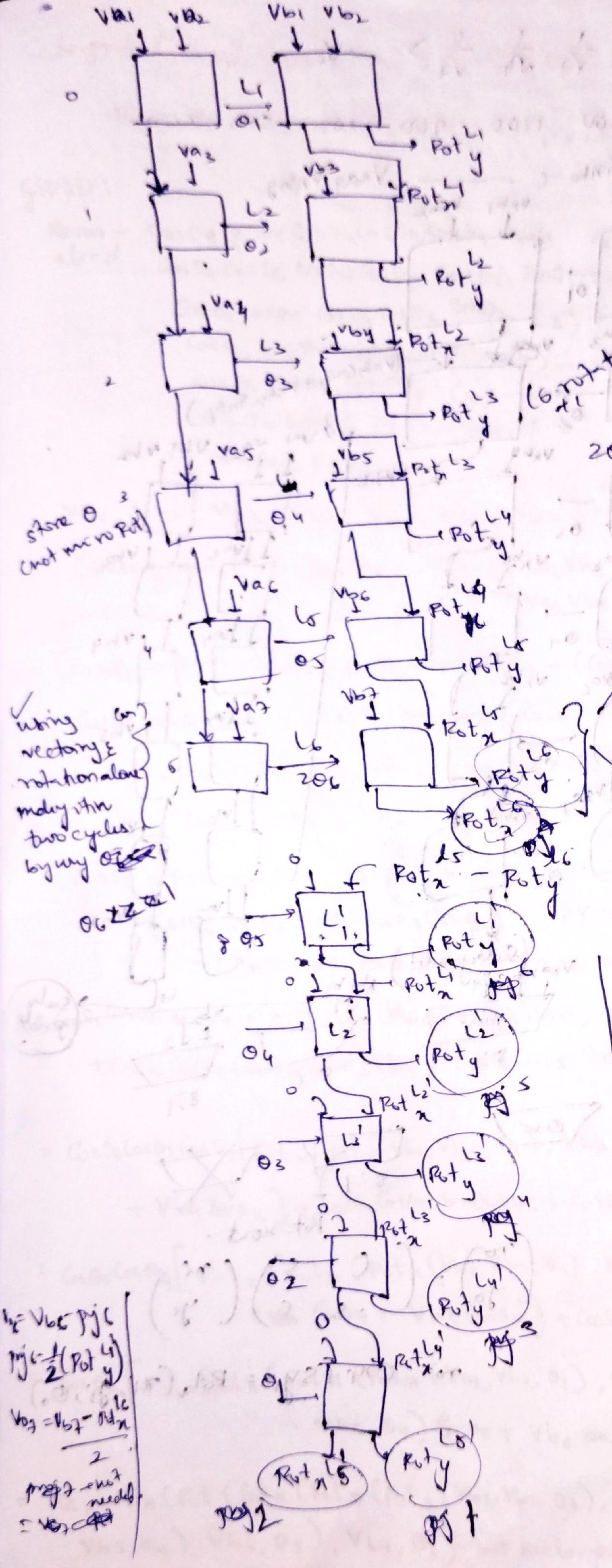
$\cos 2\theta = 2\cos^2\theta - 1$
$= 1 - 2\sin^2\theta$
$2\sin^2\theta = 1 - \cos 2\theta$

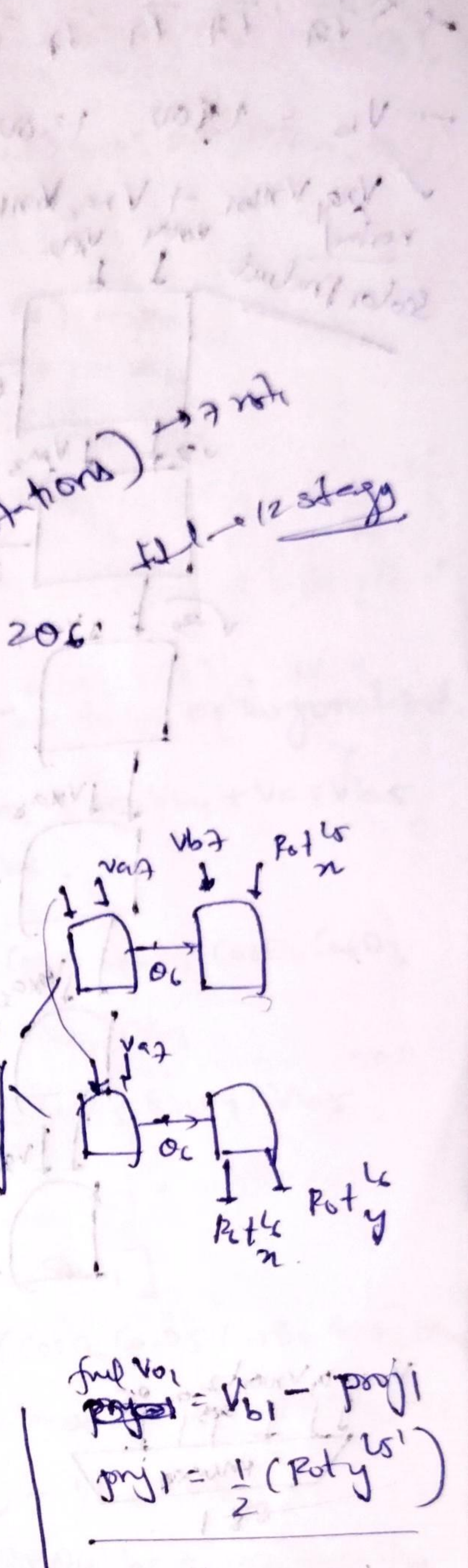
$Rot_x^{L_1} - Rot_y^{L_2}$

$(Vb_1 \cos\theta_1 + Vb_2 \sin\theta_1) - (Vb_1 \cos\theta_1 + Vb_2 \sin\theta_2)(\cos 2\theta_2) + Vb_3 \sin 2\theta_2$

$(Vb_1 \cos\theta_1 + Vb_2 \sin\theta_1)(1 - \cos 2\theta_2) + Vb_3 (\sin 2\theta_2)$

$\left((Vb_1 \cos\theta_1 + Vb_2 \sin\theta_1)(2\sin^2\theta_2) + Vb_3 (2\sin\theta_2 \cos\theta_2)\right) \cos\theta$





final $V_{o1} = V_{b1} - proj1$

$proj_1 = \frac{1}{2}(Rot_y^{L5'})$

$V_{o2} = V_{b2} - proj2$

$proj_2 = \frac{1}{2}(Rot_y^{L5'})$

$V_{o3} = V_{b3} - proj3$

$proj3 = \frac{1}{2}(Rot_y^{L4'})$

$V_{o4} = V_{b4} - proj4$

$proj4 = \frac{1}{2}(Rot_y^{L3'})$

$V_{o5} = V_{b5} - proj5$

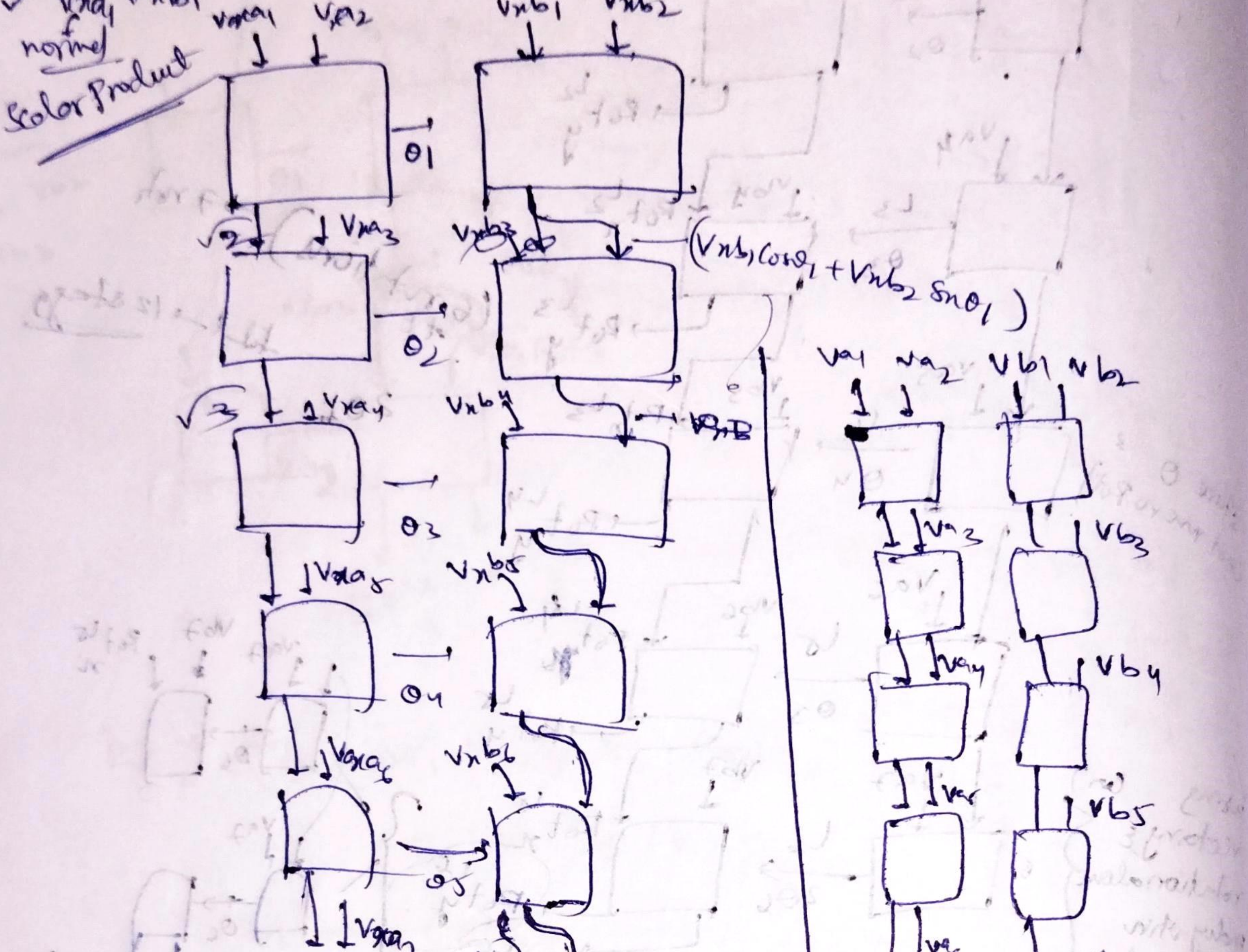
$proj5 = \frac{1}{2}(Rot_y^{L2'})$

$\rightarrow \langle \frac{1}{\sqrt{7}}, \frac{1}{\sqrt{7}}, \frac{1}{\sqrt{7}}, \frac{1}{\sqrt{7}}, \frac{1}{\sqrt{7}}, \frac{1}{\sqrt{7}}, \frac{1}{\sqrt{7}} \rangle \rightarrow V_a$

$\rightarrow V_b = 1500 \quad 1300 \quad 1100 \quad 900 \quad 700 \quad 500 \quad 300$

✓ $V_{xa_1} V_{xb_1} + V_{xa_2} V_{xb_2} + \_\_\_\_ V_{xa_7} V_{xb_7}$

normed Scalar Product



Rot_mont.

$$\begin{pmatrix} x_o \\ y_o \end{pmatrix} = \begin{pmatrix} c & s \\ -s & c \end{pmatrix} \begin{pmatrix} x_i \\ y_i \end{pmatrix}$$

$$x_o = c x_i + s y_i = Rot_x(x_i, y_i, \theta)$$

Scalarproduct → $Rot_x^6(Rot_x^5(Rot_x^4(Rot_x^3(Rot_x^2(Rot_x^1(V_{xb1}, V_{xb2}, \theta_1), V_{xb3}, \theta_2), V_{xb4}, \theta_3), V_{xb5}, \theta_4), V_{xb6}, \theta_5), V_{xb7}, \theta_6)$

GSO ID:

Normalized −
$\cos\theta_6 \cos\theta_5 \cos\theta_4 \cos\theta_3 \cos\theta_2 \cos\theta_1$ (1) − V_{a1}
$\cos\theta_6 \cos\theta_5 \cos\theta_4 \cos\theta_3 \cos\theta_2 \sin\theta_1$ (2) − V_{a2}
$\cos\theta_6 \cos\theta_5 \cos\theta_4 \cos\theta_3 \sin\theta_2$ (3) − V_{a3}
$\cos\theta_6 \cos\theta_5 \cos\theta_4 \sin\theta_3$ (4) − V_{a4}
$\cos\theta_6 \cos\theta_5 \sin\theta_4$ (5) − V_{a5}
$\cos\theta_6 \sin\theta_5$ (6) − V_{a6}
$\sin\theta_6$. (7) − V_{a7}

$V_{b1}, V_{b2}, V_{b3}, V_{b4}, V_{b5}, V_{b6}, V_{b7}$. → to be orthogonalized.

$$(\text{scalarproduct}) = V_{a1}V_{b1} + V_{a2}V_{b2} + V_{a3}V_{b3} + V_{a4}V_{b4} + V_{a5}V_{b5} + V_{a6}V_{b6}.$$

$$= (\cos\theta_6 \cos\theta_5 \cos\theta_4 \cos\theta_3 \cos\theta_2 \cos\theta_1)V_{b1} + (\cos\theta_6 \cos\theta_5 \cos\theta_4 \cos\theta_3 \cos\theta_2 \sin\theta_1)V_{b2} + (\cos\theta_6 \cos\theta_5 \cos\theta_4 \cos\theta_3 \sin\theta_2)V_{b3} + (\cos\theta_6 \cos\theta_5 \cos\theta_4 \sin\theta_3)V_{b4} + (\cos\theta_6 \cos\theta_5 \sin\theta_4)V_{b5} + (\cos\theta_6 \sin\theta_5)V_{b6} + (\sin\theta_6)V_{b7}$$

$$= \cos\theta_6 \cos\theta_5 \cos\theta_4 \cos\theta_3 \cos\theta_2 [V_{b1}\cos\theta_1 + V_{b2}\sin\theta_1] + (\cos\theta_6 \cos\theta_5 \cos\theta_4 \cos\theta_3 \sin\theta_2)V_{b3} + (\cos\theta_6 \cos\theta_5 \cos\theta_4 \sin\theta_3)V_{b4} + (\cos\theta_6 \cos\theta_5 \sin\theta_4)V_{b5} + (\cos\theta_6 \sin\theta_5)V_{b6} + (\sin\theta_6)V_{b7}$$

$$= \cos\theta_6 \cos\theta_5 \cos\theta_4 \cos\theta_3 [Rot_x(V_{b1}, V_{b2}, \theta_1)\cos\theta_2 + V_{b3}\sin\theta_2] + \cos\theta_6 \cos\theta_5 \cos\theta_4 \sin\theta_3 V_{b4} + \cos\theta_6 \cos\theta_5 \sin\theta_4 V_{b5} + \cos\theta_6 \sin\theta_5 V_{b6} + \sin\theta_6 V_{b7}$$

$$= \cos\theta_6 \cos\theta_5 \cos\theta_4 [Rot_x(Rot_x(V_{b1}, V_{b2}, \theta_1), V_{b3}, \theta_2)\cos\theta_3 + V_{b4}\sin\theta_3] + \cos\theta_6 \cos\theta_5 \sin\theta_4 V_{b5} + \cos\theta_6 \sin\theta_5 V_{b6} + \sin\theta_6 V_{b7}$$

$$= \cos\theta_6 \cos\theta_5 [Rot_x(Rot_x(Rot_x(V_{b1}, V_{b2}, \theta_1), V_{b3}, \theta_2), V_{b4}, \theta_3)\cos\theta_4 + V_{b5}\sin\theta_4] + \cos\theta_6 \sin\theta_5 V_{b6} + \sin\theta_6 V_{b7}$$

$$= \cos\theta_6 [Rot_x(Rot_x(Rot_x(Rot_x(V_{b1}, V_{b2}, \theta_1), V_{b3}, \theta_2), V_{b4}, \theta_3), V_{b5}, \theta_4)\cos\theta_5 + V_{b6}\sin\theta_5] + V_{b7}\sin\theta_6$$

$$= Rot_x(Rot_x(Rot(Rot_x(Rot_x(Rot_x(V_{b1}, V_{b2}, \theta_1), V_{b3}, \theta_2), V_{b4}, \theta_3), V_{b5}, \theta_4), V_{b6}, \theta_5), V_{b7}, \theta_6)$$ → scalarproduct.

(378, 378, 378, 378, 378, 378, 378)

(1000, 2000, 3000, 4000, 5000, 6000, 7000)

scalar product = 378000 (1+2+3+4+5+6+7) $\frac{7\times8}{2} = 28$

= 378000 × 28 = 10584000

$2^{16} = 65536$

~~too~~ 1 2 3 4 5 6 7

378 378 378 378 378 378 378 → 10584 → expected scalar product

GSO → Vout1, Vout2, Vout3, Vout4, Vout5, Vout6, Vout7.

Vout1 = Vb1 − (scalar product) * Va1

= Vb1 − (10584) * (378)

1 2 3 4 5 6 7

0.378 × 7 7×4 − 28 × 0.378 = 10.584

10.584 1 − (10.584)(0.378) = −3.000752

10584 2 − (10.584) = −2.000752

{1000 2000 3000 4000 5000 6000 7000 = −1.000752

{378 378 378 378 378 378 378 = 0.000752

10584000 >>> 3 → 10584 → Rot_n = 1.000752

~~10584~~ = 2.000752

1000 − 378 × 10584 ⇐ Rn >>> 6 = 3.000752

proj >>> 3 → 4000.752

↓

calculations

① $Va_1, Va_2 = 378$ } $\sqrt{2} \times 378 = 534$ → V_n → demux 1 ✓

mux1, mux2 — $45° \to 8193$ → angle → demux 2 ✓

$Vb_1, Vb_2 = 1000, 2000$

mux3, mux4

$= 1000\left(\frac{1}{\sqrt2}\right) + 2000\left(\frac{1}{\sqrt2}\right) = 2121$ → demux 3

$-1000\left(\frac{1}{\sqrt2}\right) + 2000\left(\frac{1}{\sqrt2}\right) = X$ → demux 4

$\begin{pmatrix} Vb_1 \\ Vb_2 \end{pmatrix} = \begin{pmatrix} c & s \\ -s & c \end{pmatrix} \begin{pmatrix} Va_1 \\ Va_2 \end{pmatrix}$

$Vb_1 = c\,Va_1 + s\,Va_2$

$Vb_2 = -s\,Va_1 + c\,Va_2$

$\frac{2}{\sqrt2} - \frac{1}{\sqrt2} = \frac{1}{\sqrt2}$

$\sqrt3 \times 378 = 654$

$\tan^{-1}\left(\frac{1}{\sqrt2}\right) = 6427$ ✓

$2^{16} = 360$

$x = 6384$

$x = \frac{26.56}{360} \times 2^{16}$

65536

$\frac{1}{\sqrt2}$ $\frac{1}{\sqrt3}$ $\frac{\sqrt2}{\sqrt3}$

$3000\left(\frac{\sqrt2}{\sqrt3}\right) + 2121\left(\frac{1}{\sqrt3}\right) = 3673$

⑧

	①	②	③	④	⑤	⑥	⑦
Mux1 –	378	534	654	755	844	924	—
Mux2 –	378	378	378	378	378	378	—
Mux3 –	1000	3000	4000	5000	6000	—	7000
Mux4 –	2000	2121	3673	5301	6843	—	8272
demux1 –	534	654	755	844	924	998	—
demux2 –	8193	6427	5467	4843	4391	4051	—
demux3 –	2121	3673	5301	6843	8272	—	10790
demux4 –	—	—	—	—	—	—	991
	θ_1	θ_2	θ_3	θ_4	θ_5		θ_6
	000	001	010	011	100	101	110

$\sqrt{4} \times 378 =$

$\tan^{-1}\left(\frac{1}{\sqrt3}\right)$

$(3673)\left(\frac{\sqrt3}{2}\right) + (4000)\left(\frac{1}{2}\right)$

4 5309

$\tan^{-1}\left(\frac{1}{2}\right) = 26 \to 4855$

$5000\left(\frac{2}{\sqrt5}\right) + 5301\left(\frac{1}{\sqrt5}\right)$

$\tan^{-1}\left(\frac{1}{\sqrt5}\right)$ 6844

$6000\left(\frac{\sqrt5}{\sqrt6}\right) + 6843\left(\frac{1}{\sqrt6}\right)$

2×4051

8102

10790

$2\tan^{-1}\left(\frac{1}{\sqrt6}\right)$ ✓

$\cos 2\theta = \frac{1 - \tan^2\theta}{1 + \tan^2\theta}$

$\sin 2\theta = \frac{2\tan\theta}{1 + \tan^2\theta}$

10790 991

$\frac{1 - \left(\frac{1}{6}\right)}{1 + \left(\frac{1}{6}\right)}$ 25 24

$\frac{2\left(\frac{1}{\sqrt6}\right)}{1 + \frac{1}{6}}$

$\frac{5}{7}$ $\frac{2\sqrt6}{7}$

$(\sqrt6)^2 + 4$ $\frac{5}{7}$

28 ✓

(till 7 cycles → exactly all rot values correct ✓)

$\frac{5}{7}(7000) + \left(\frac{2\sqrt6}{7}\right)(8272) = 10789$ ~~5385.7~~ ✓

~~991~~ ✓

$\frac{5}{7}(7000) - \frac{2\sqrt6}{7}(8272) = $ ~~789.19~~ ✓

mux 1, 2 ✗

demux 1, 2 → 111, L_1'

$378\left(\frac{7 \times 8}{2}\right)$

28×378

	⑧		⑨		⑩
Mux3	0		0		0
Mux4	7281		2976		1332
demux3	2976 ✓	→ 2976	1332 ✓		666 ✓
demux4	6644 ✓	→ 6644	2660 ✓		1153 ✓
	$\theta_5 = 4391$		$\theta_4 = 4843$		$\theta_3 = 5467$

⑨ → L_2' 8272, 2.99 → L_3'

⑪ → L_4'

0

666

384 ✓

543 ✓

$\theta_2 = 6427$

⑫ → L_5'

0

384

271 ✓

271

$\theta_1 = 8193$

(7) values

271, 271, 543, 1153, 2660, 6644, 10790
(L'5) (L'5) (L'4) (L'3) (L'2) (L'1) L6

Gso: (1) → $1000 - \frac{271}{2} = 864.5$ ✓

(2) → $2000 - \frac{271}{2} = 1864.5$ ✓

(3) → $3000 - \frac{543}{2} = 2728.5$ ✓

(4) → $4000 - \frac{1153}{2} = 3423.5$ ✓

(5) → $5000 - \frac{2660}{2} = 3670$ ✓

(6) $6000 - \frac{6644}{2} = 2678$ ✓

(7) $\frac{7000 - 10790}{2} = -1895$ ✓

converts to 2's complement

$2^{16} - 1895$

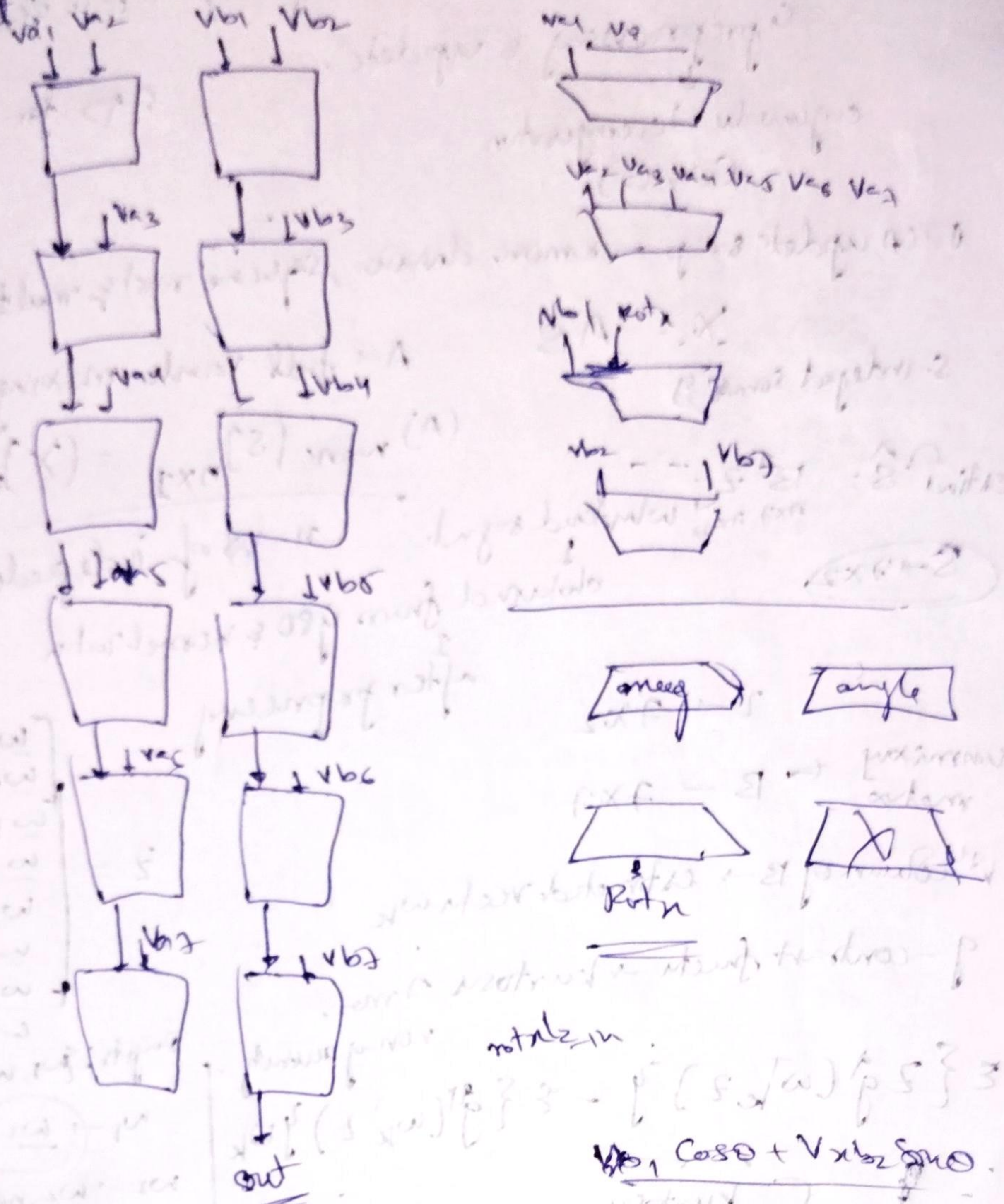
$65536 - 1895 = 63641$ 11111
63641

Scalar product → 4 mux, 3 demux 4 all 8 5 1
not in L6 - ~~out~~

total steps → 7 only signed so 3 bit vector ✓

378 378 378 378 378 378 378
1000 2000 3000 4000 5000 6000 7000

scalar product :



$V_{b1}\cos\theta + V_{xb2}\sin\theta$

378	378	378	378	378	378	378.
1000	2000	3000	4000	5000	6000	7000

	1	2 $\frac{1}{\sqrt{2}}$	3 $\frac{1}{\sqrt{3}}$	4 $\frac{1}{2}$	5 $\frac{1}{\sqrt{5}}$	6 $\frac{1}{\sqrt{6}}$
mux 1	378	534	654	~~755~~	844	924
mux 2	378	378	378	378	378	378
mux 3	1000	2121	3464	5000	6709	8575
mux 4	2000	3000	4000	5000	6000	7000
demux 1	534	654	755	844	~~844~~ 924	998
demux 2	8293	6427	5467	4843	4891	4051
dem 3	2121	3464	5000	6709	8575	10584

yay

$1000\left(\frac{1}{\sqrt{2}}\right) + 2000\left(\frac{1}{\sqrt{2}}\right) = 500\sqrt{2} + 1000\sqrt{2} = 2121$

$2121\left(\frac{\sqrt{2}}{\sqrt{3}}\right) + 3000\left(\frac{1}{\sqrt{3}}\right) = 3464$

$3464\left(\frac{\sqrt{3}}{2}\right) + 4000\left(\frac{1}{2}\right) = 5000$

$5000\left(\frac{2}{\sqrt{5}}\right) + 5000\left(\frac{1}{\sqrt{5}}\right) = 6709$

$6709\left(\frac{\sqrt{5}}{\sqrt{6}}\right) + 6000\left(\frac{1}{\sqrt{6}}\right) = 8575$

$8575\left(\frac{\sqrt{6}}{\sqrt{7}}\right) + 7000\left(\frac{1}{\sqrt{7}}\right)$

10584 — scal prod

→ Coordinate Rotation based low complexity

↳ preprocessing & update.

eigenvalue decomposition (EVD)

7D for 2 vectors.

FICA update step – remove division, square root & multiplication.

$X = AS$ A – full rank mixing matrix

S – independent sources

$(A)_{n \times n} [S]_{n \times 2} = (X)_{n \times 2}$

n – no. of independent sources] dimensions

estimate $\hat{S} = B^T_{7 \times 7} Z_{7 \times 2}$ ← whitened signal.

obtained from GSO & normalization after preprocessing

$\hat{S} \to 7 \times 2$

$Z \to 7 \times 2$

unmixing matrix ← $B \to 7 \times 7$.

$$Z = \begin{bmatrix} w_{11} & w_{21,new} \\ w_{12} & w_{22,n} \\ w_{13} & w_{23,n} \\ w_{14} & w_{24,n} \\ w_{15} & w_{25,n} \\ w_{16} & w_{26,n} \\ w_{17} & w_{27,n} \end{bmatrix}_{7 \times 2}$$

k^{th} column of B → estimated vector w_k

g – contrast function → kurtosis → max. non-gaussianity

$$\varepsilon \{ Z g'(w_k^T Z) \} - \varepsilon \{ g''(w_k^T Z) \} w_k$$

kurtosis

$$\varepsilon \{ Z (w_{k-1}^T Z)^3 \} - 3 w_{k-1} \to w_k$$

if $k = 1 \to w_k \leftrightarrow \frac{w_k}{\| w_k \|}$

Inputs: $\{w_1, w_2\}$

$w_1 \to \underline{w_1} \to$ (8n Normalized)

$w_2 \to \underline{w_2}, new$ (GSO for $\underline{w_1}$ & w_2)

$w_{2,new} \to \underline{w_{2,new}}$ (8n norm.)

for B^T also it is like

k^{th} column of B → estimated vector w_k

so, w_1 (normalized only estimated)

w_2 again estimated & filled.

w_1 w_2 w_3 w_4 w_5 w_6 w_7

$$B = \begin{bmatrix} w_{11} \\ w_{12} \\ w_{13} \\ w_{14} \\ w_{15} \\ w_{16} \\ w_{17} \end{bmatrix}_{7 \times 7}$$

$w_1 \leftarrow w_1 / \| w_1 \|$

✓ $w_2 \leftarrow \varepsilon \{ Z (w_1^T Z)^3 \} - 3 w_1$

$w_3 \leftarrow \varepsilon \{ Z (w_2^T Z)^3 \} - 3 w_2$

$w_4 \leftarrow \varepsilon \{ Z (w_3^T Z)^3 \} - 3 w_3$

w_5 w_6 w_7 ✓

↳ update block.

$w_1 = 7 \times 1$ $Z = \underline{w_1}$ (GSO & n)

$w_1^T = 1 \times 7$ $Z = 7 \times 1$

$w_1^T Z = 1 \times 1$

$Z_{7 \times 1} \times k - 3 w_{1, 7 \times 1}$

$w_2 \to 7 \times 1$

2D → 2 vectors.

$$\begin{bmatrix} w_{1,1}^{p+1} \\ w_{1,2}^{p+1} \end{bmatrix} = \begin{bmatrix} \varepsilon[z_{1,j}\{z_{1,j}\underline{w}_{1,1}^{(p)} + z_{2,j}\underline{w}_{1,2}^{p}\}^3 - 3\underline{w}_{1,1}^{p}] \\ \varepsilon[z_{2,j}\{z_{1,j}w_{1,1}^{(p)} + z_{2,j}\underline{w}_{1,2}^{p}\}^3 - 3w_{1,2}^{p}] \end{bmatrix}$$

scalar product

p - iterations

$z_{1,j}$ → 1st vector, j - no. of samples ∈ (1, m)

frame-length - dimensions?

$w_{1,1}^{(p+1)}$, $w_{1,2}^{(p+1)}$ } 1st column after p^{th} iteration.

$\underline{w}_{1,q}^{(p)}$ - normalized value of $\underline{w}_{1,q}^{(p)}$ end in p^{th} iteration

$\underline{w}_{1,1}^{(p)}$ → $\cos\theta_p$ $\sin\theta_p$. $\theta_p = \tan^{-1}\left(\dfrac{\underline{w}_{1,2}^{(p)}}{\underline{w}_{1,1}^{(p)}}\right)$

$\underline{w}_{1,2}^{(p)}$.

$$\hat{s}_{1,j} = z_{1,j}\underline{w}_{1,1} + z_{2,j}\underline{w}_{1,2} = \mathrm{Rot}_n(z_{1,j}, z_{2,j}, \mathrm{vec}_0(\underline{w}_{1,1}^{c}, w_{1,2}^{c}))$$

for 3D:

$$g_{3D} = z_{1,j}\underline{w}_{1,1}^{(p)} + z_{2,j}\underline{w}_{1,2}^{(p)} + z_{3,j}\underline{w}_{1,3}^{(p)}$$

scalar product

$$\underline{w}_{1,1}^{(p+1)} = \varepsilon[z_{1,j}(g_{3D})^3] - 3\underline{w}_{1,1}^{(p)}$$

$$w_{1,2}^{(p+1)} = \varepsilon[z_{2,j}(g_{3D})^3] - 3\underline{w}_{1,2}^{(p)}$$

$$w_{1,3}^{(p+1)} = \varepsilon[z_{3,j}(g_{3D})^3] - 3\underline{w}_{1,3}^{(p)}.$$

~~$z_{1,j}, z_{2,j}$~~ $z^T = [z_1, z_2, z_3, z_4, z_5, z_6, z_7]$ → 7D

one vector

one vector $w^T = [w_{1,1}, w_{1,2}, w_{1,3} \ldots w_{1,7}]$ → 7D

estimation → scalar product $w^T z$. $w \to V_{na}$

$z \to V_{nb}$.

$\varepsilon\{z(\text{~~scalar~~ estimate}_p)^3$

$\varepsilon\{V_{nb}(\text{sclr pr})^3\} - 3V_{na}$

$\hat{S} = B^T z$
$7\times2 \quad 7\times2 \quad 7\times2$

I think → w_k → orthogonalised vectors → $\underline{w}_{1,new}, w_{2,new}$ ...

$\boxed{z = w_{1,1} \ldots w_{1,7}}$

~~$w_{2,1} \ldots w_{2,7}$~~

$z = 7\times2$

$\boxed{w_{1,1} \ldots w_{1,7}}$ } w_k

~~$w_{2,1}$ new ... $w_{2,7}$ new~~

$w = 7\times2$

$w^T = 2\times7$

$w_k^T z = 2\times7\ \ 7\times2 = \cancel{2\times2}$

before normalization, vectors should be good.