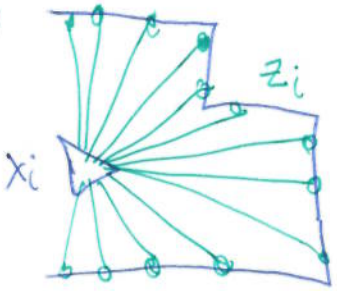
* Point Cloud Registration

PC here can be 3D or 2D, set of points

Ex:



$z_i = \{ p_1, p_2, \dots, p_K \}$

points from sensor (range-finder) observed at pose x_i.

Problem: find the transformation from a pair of poses x_i, x_j, such that (homogeneous coord)

$$\boxed{{}^jT_i \, z_i = z_j}$$

for all points in z.

Called registration, alignment, scanmatching (2D)

Now, this definition considers 2 unrealistic things:

1- point to point correspondences is correct.

2- we sample the same points from x_i and x_j

* SVD methods (Arun '87)

If we have enough points, we can assume true the previous considerations

then, we define a cost function to minimize.

$$J(z_i, z_j) = \sum_{k}^{K} \| z_j^k - {}^jT_i \, z_i^k \|^2$$

the solution is found by decoupling translation and Rotation:

$$^{j}t_i + E\{z_i\} = E\{z_j\}$$ (same centroids translated)

and then apply an SVD solution of a cross term Σ_{z_i,z_j}.

Only 2 points in 2D
3 points in 3D.

Drawbacks:

sensitive to outliers
requires known correspondences

* RANSAC (Fischler '81)

↳ Random sample consensus (General alg. for param. estimation)

We reject/eliminate outliers by sampling a subset of observation correspondences z_j', z_i' minimal for solving:

- SVD-registration $(z_j', z_i') = {}^{j}T_i'$ solve the registrat.
- $J(z_i, z_j, {}^{j}T_i')$ test the hypothesis.

Create a consensus set

* Iterative closest point (ICP)

given two point clouds, z_i , z_j with no a priori correspondences.

1) find closest points

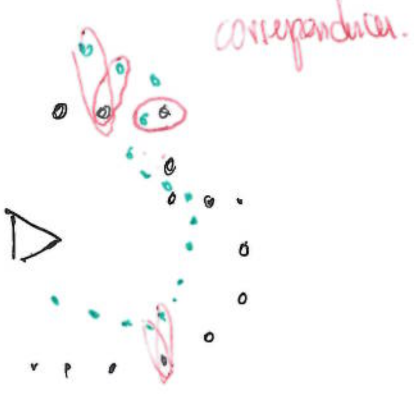
$$d(p_i, z_j) = \min_{p_{z_j} \in z_j} \| p_{z_j} - p_i \| \quad , \quad p_i \in z_i \quad (p_i \in {}^jT_i z_i)$$

Brute force search of a single point vs all the other points. (kd-tree)

2) Align the pointcloud z_j and $\{ p_i \}$ with correspondences.

3) Do while convergence.

Ex:



Of course there will be outliers but iteratively we get rid of them.

SVD techniques are not the most convenient. ⇒
Gradient based techniques work best.

$${}^jT_i := {}^jT_i^0 \oplus \alpha \nabla_T J(z_i, z_j)$$

(next ProbRob Ch9)