Estimating Individualized Treatment Effects from Real-world Patient Data with Deep Latent Models

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- Challenges of using observational data for estimating ITEs
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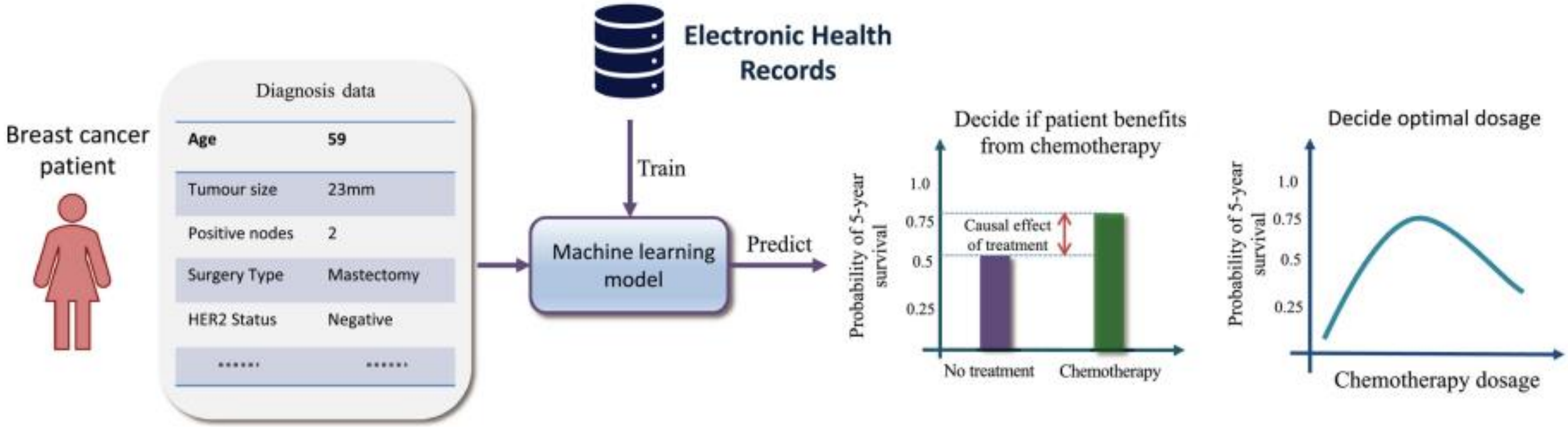
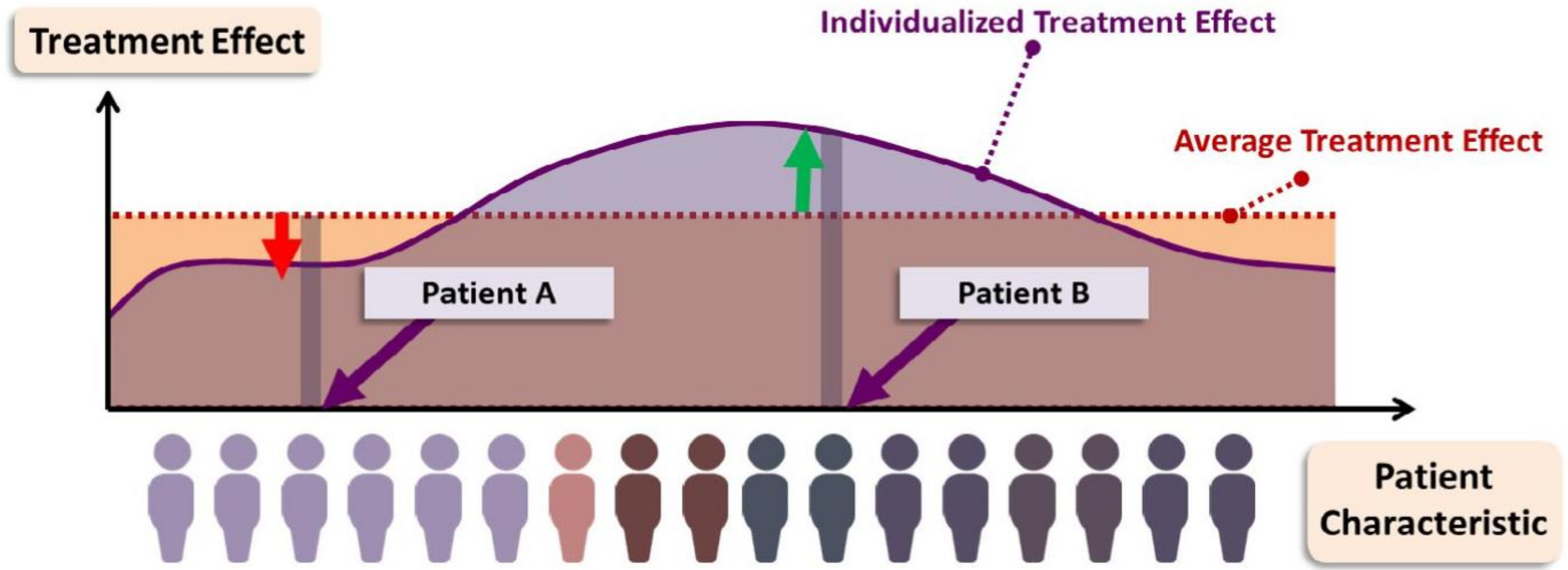
Introduction of Individualized treatment effects (ITEs)

- Personalized therapeutics



Introduction of Individualized treatment effects (ITEs)

- Randomized controlled trials (RCTs)



Introduction of Individualized treatment effects (ITEs)

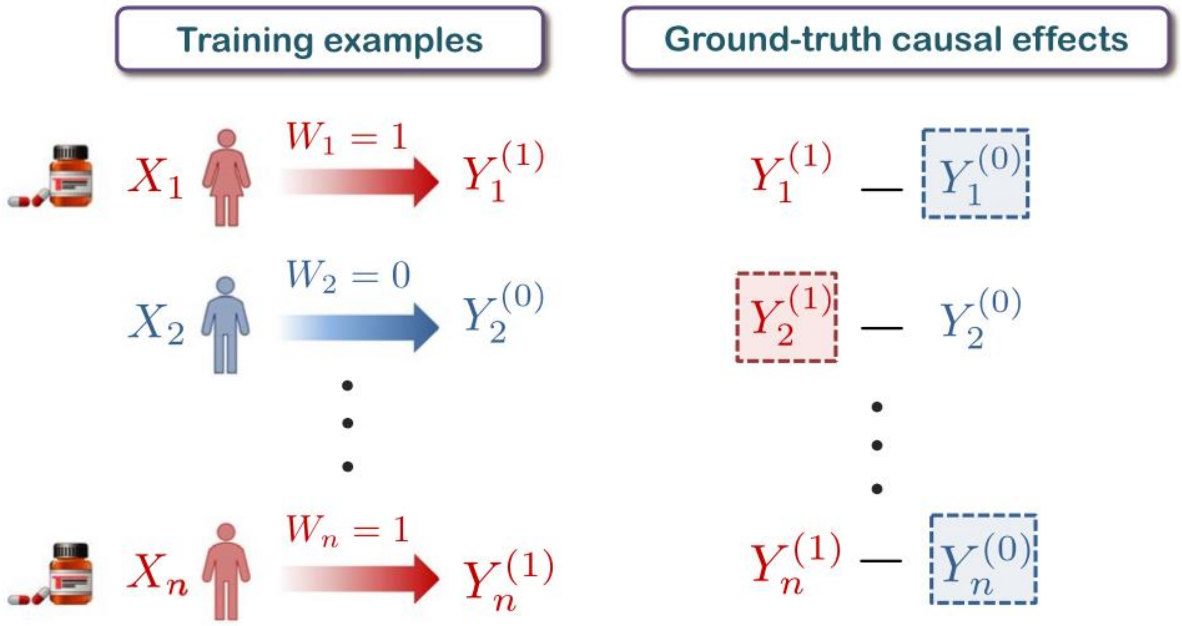
- Average treatment effects – population level
  - Small sample size
  - Not representative for heterogeneous patients
  - Costly and time consuming

Introduction of Individualized treatment effects (ITEs)

- Individual treatment effects (ITEs) – patient-centric
- Estimate ITEs from observational data, e.g. electronic health records
  - Large volume
  - Representative for heterogeneous patients
  - Fast and inexpensive
  - Scalable and adaptive

Challenges of using observational data for estimating ITEs

- Difficulty of applying supervised machine learning models
  - Counterfactuals – answering “What if?” questions



We never observe counterfactual outcomes

Not a simple supervised ML problem – no explicit label

Challenges of using observational data for estimating ITEs

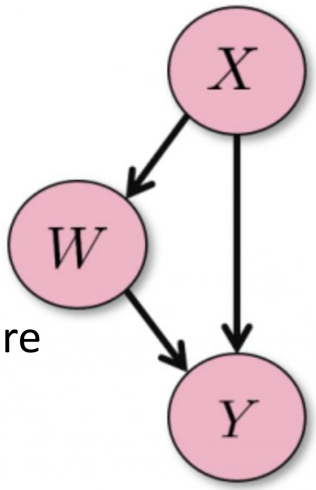
- Limitation of using observational data
  - Unmeasured variables – hidden factors
    - Socio-economic status
    - Personal preferences
    - Most genetic & environmental factors
  - Proxy variables
    - E.g. socio-economic status → zip code & job type

Challenges of using observational data for estimating ITEs

- Answering the question “will a treatment benefit for an individual patient?” from observational data is difficult because of
  - Confounding
  - bias

Formalize as causal questions

Intervention (medication, procedure etc.)

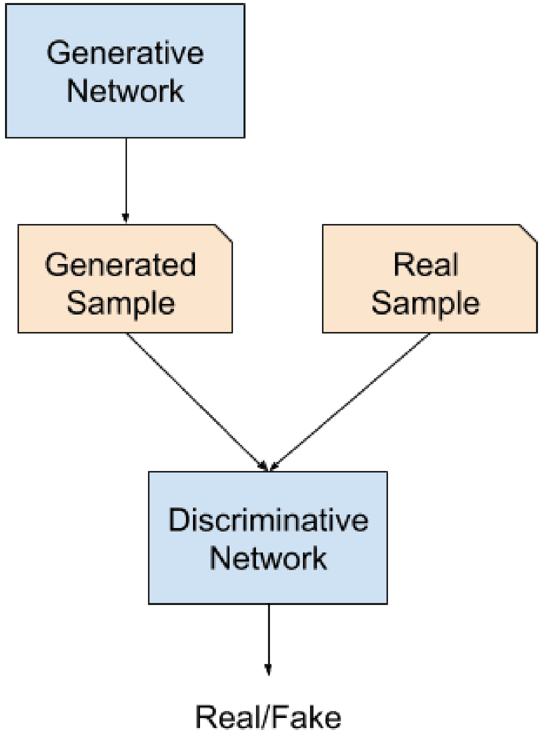


Patient (All confounding factors)

Outcome

Deep latent models for estimating ITEs

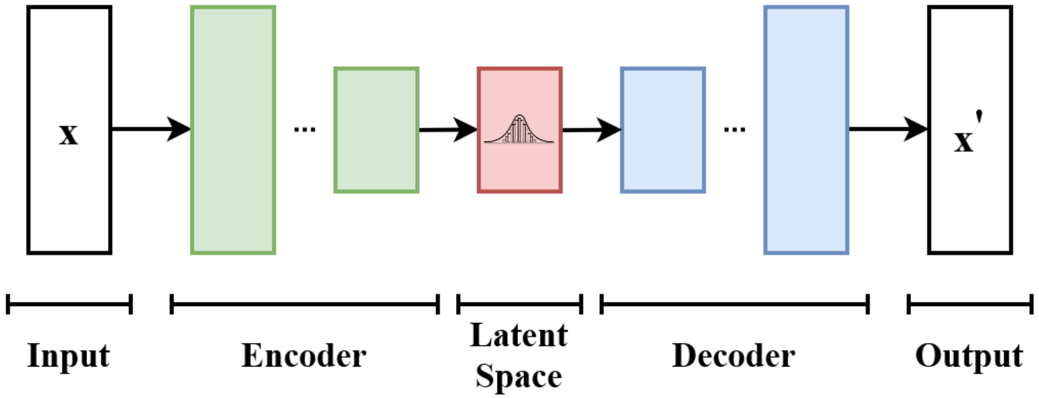
- Generative adversarial nets (GANs)



GANs can be used to create new plausible samples on demand

Deep latent models for estimating ITEs

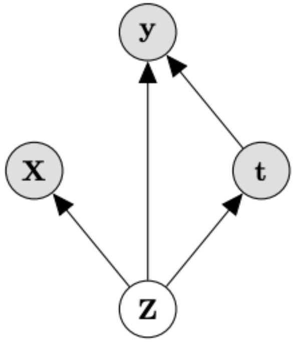
- Variational autoencoders (VAEs)

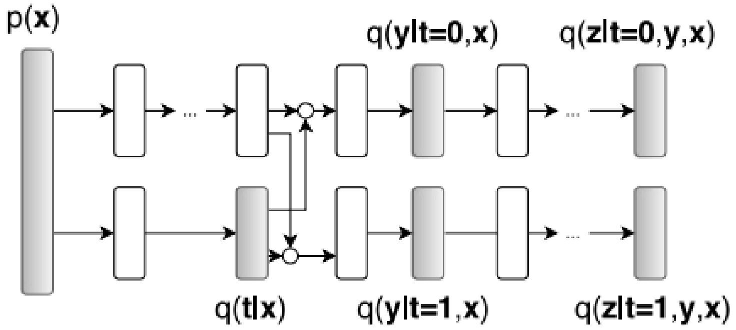


The encoder of VAE transforms input X into the latent space

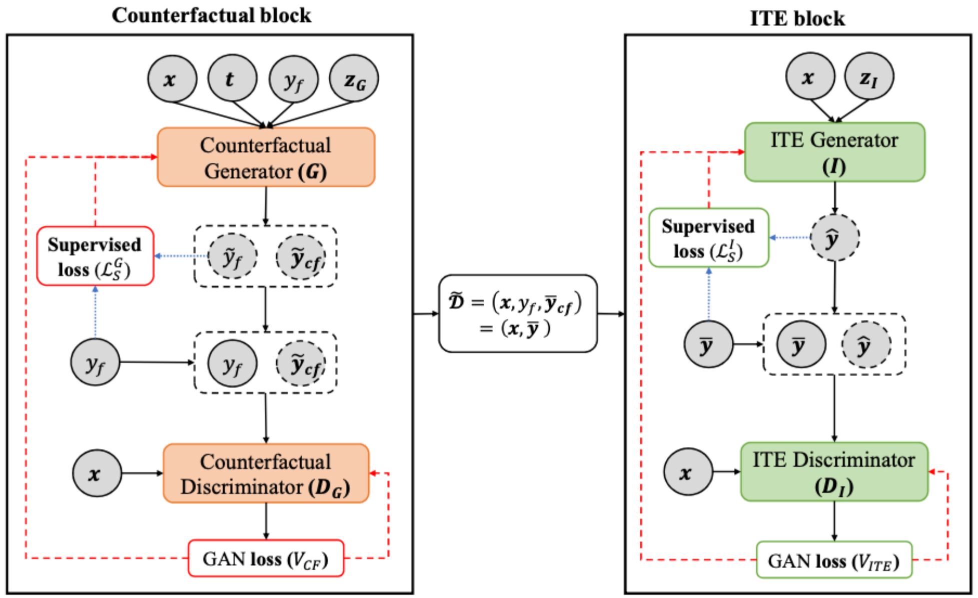
Recent progress

CEVAE: Causal effect inference with
deep latent-variable models
[Louizos, Shalit, Mooij, Sontag, Zemel, & Welling.(2017)]



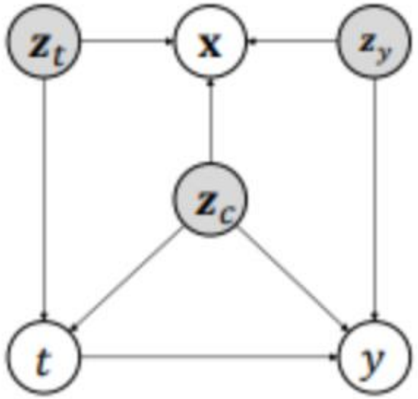


Ganite: Estimation of individualized treatment
effects using generative adversarial nets
[Yoon, Jordon, Van Der Schaar. (2018)]

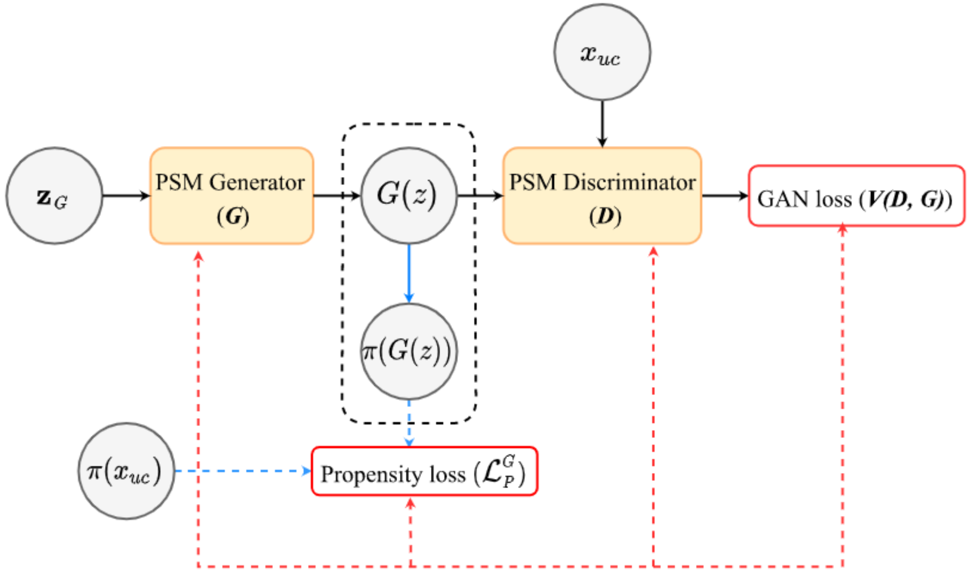


Recent progress

TEDVAE: Treatment effect estimation with disentangled latent factors
[Zhang, Liu, & Li. (2020)]

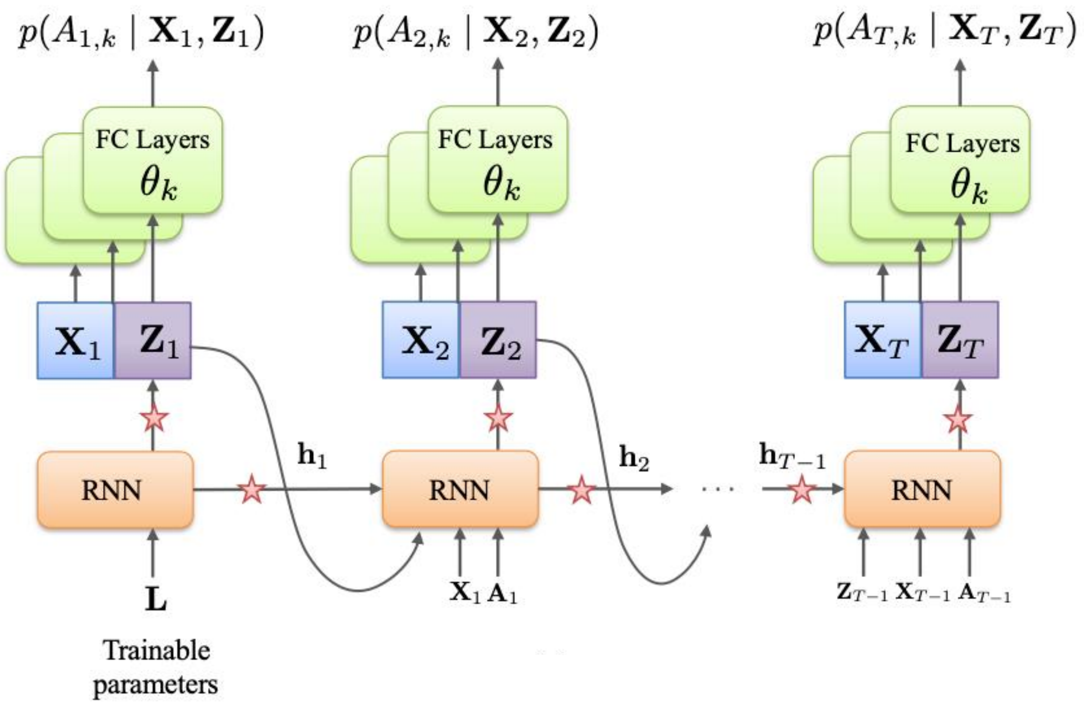


PSSAM-GAN: Propensity score synthetic augmentation matching using generative adversarial networks
[Ghosh, Boucher, Bian, & Prosperi. (2021)]



Variational temporal deconfounder

- Estimating ITEs with variational RNN on temporal clinical data



Proposed variational temporal deconfounder implementation

Thank you