Limitations of Current Approaches

Machine Learning Workflow

Li & Deng (2015)

Annotated data of student emotions

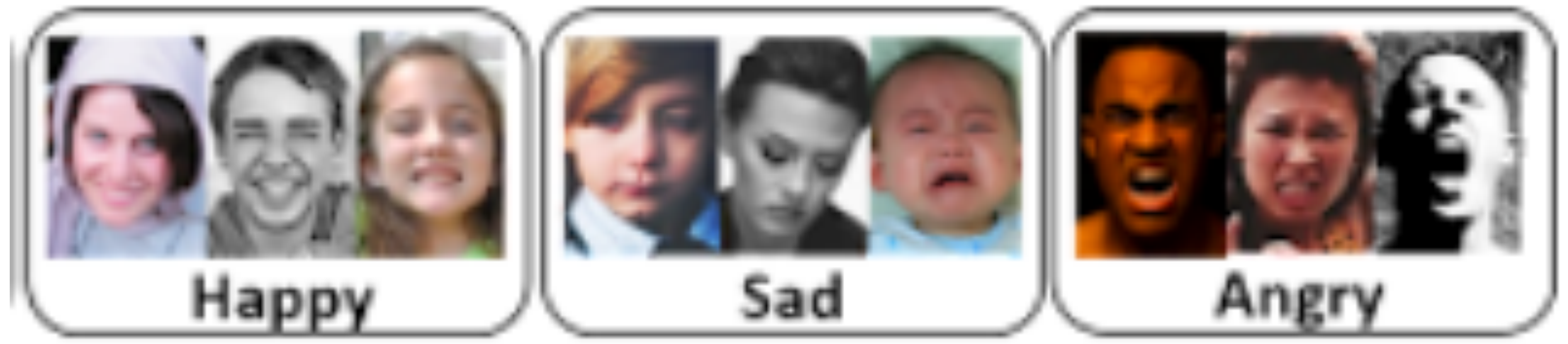
Nye et al. (2018)

DETECTOR

Engaged
Concentration

Kearns, CIS 399

- Gather sample S from P
  $\{<x_1,y_1>, <x_2, y_2>,\dots.<x_n, y_n>\}$



RAF

Machine Learning Workflow

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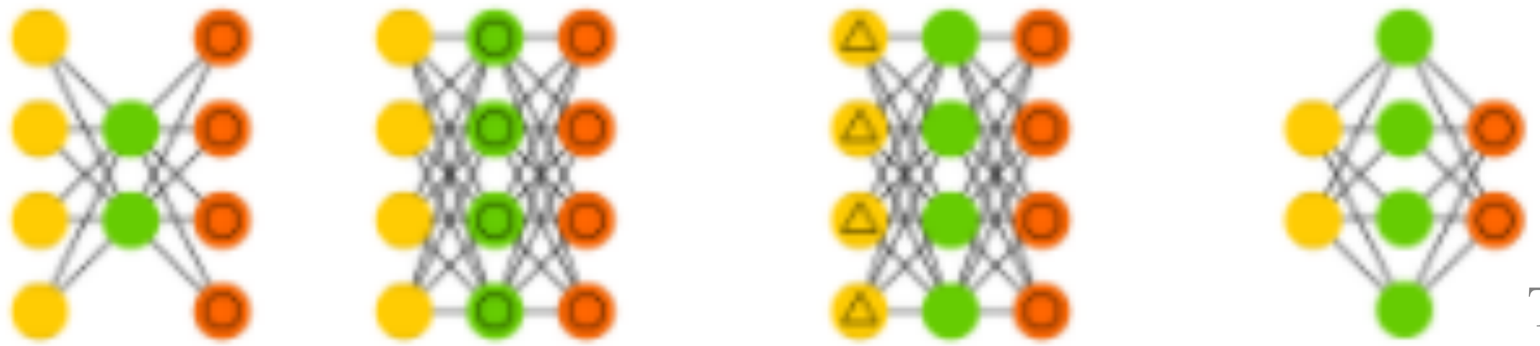
DETECTOR

Engaged Concentration

Kearns, CIS 399

- Gather sample S from P $\{<x_1,y_1>, <x_2, y_2>, \ldots .<x_n, y_{n>}\}$
- Design/choose model class H



Tch

Machine Learning Workflow

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DETECTOR

Engaged Concentration

Kearns, CIS 399

- Gather sample S from P $\{<x_1,y_1>, <x_2, y_2>,....<x_n, y_{n>}\}$
- Design/choose model class H
- Use algorithm/heuristic to find $h \in H$ with small error $\hat{e}(h)$

Tch

Machine Learning Workflow

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DETECTOR

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Kearns, CIS 399

- Gather sample S from P $\{<x_1,y_1>, <x_2, y_2>,\ldots.<x_n, y_{n>}\}$
- Design/choose model class H
- Use algorithm/heuristic to find $h \in H$ with small error $\hat{e}(h)$
- Estimate $e(h)$ on new data also from P

Machine Learning Workflow

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DETECTOR

Engaged Concentration

Kearns, CIS 399

- Gather sample S from P
  $\{\langle x_1,y_1\rangle, \langle x_2, y_2\rangle, \ldots \langle x_n, y_n\rangle\}$
- Design/choose model class H
- Use algorithm/heuristic to find $h \in H$ with small error $\hat{e}(h)$
- Estimate $e(h)$ on **new** data **also from P**

Learning = **generalization**

Fundamental Theorem of Machine Learning

Learning = **generalization**

Kearns, CIS 399

No matter what P looks like…

…and for any reasonable H…

…if we have **enough data** S…

…then for **every h $\in$ H**, we have

$$\hat{e}_S(h) \approx e_P(h)$$

DETECTOR

- Gather sample S from P $\{<x_1,y_1>, <x_2, y_2>, \ldots . <x_n, y_n>\}$
- Design/choose model class H
- Use algorithm/heuristic to find h $\in$ H with small error $\hat{e}(h)$
- Estimate e(h) on **new** data **also from P**

But Learning Context Varies Widely

Generalization to Student Subgroups

Kearns, CIS 399

No matter what P looks like…

…and for any reasonable H…

…if we have **enough data** S…

…then for **every h ∈ H**, we have

minimizing error on **data**
≈
minimizing **true/future** error

DETECTOR

- Gather sample S from P $\{<x_1,y_1>, <x_2, y_2>,\ldots.<x_n, y_n>\}$
- Design/choose model class H
- Use algorithm/heuristic to find $h \in H$ with small error $\hat{e}(h)$
- Estimate e(h) on new data also from P

Student population not reported with generalization estimates (Paquette et al., 2020)

The Problem of Bias

No matter what P looks like…

…and for any reasonable H…

…if we have **enough data** S…

…then for every **h** ∈ **H**, we have

minimizing error on **data**

≈

minimizing **true/future** error

DETECTOR

"All models are wrong
but some are useful"
- George Box

The Problem of Bias

No matter what P looks like…

…and for any reasonable H…

…if we have **enough data** S…

…then for **every h** $\in$ **H**, we have

minimizing error on **data**

$\approx$

minimizing **true/future** error

DETECTOR

Politico

Haley Falcon

The Wire

Karumbaiah, S., & Brooks, J. (2021) How Colonial Continuities Underlie Algorithmic Injustices in Education. [IEEE RESPECT21]

Current Downstream Efforts

Focus on Model Development and Evaluation

No matter what **P** looks like…

…and for any reasonable H…

…if we have **enough data** S…

…then for **every h ∈ H**, we have

minimizing error on **data**

$\approx$

minimizing **true/future** error

DETECTOR

Study	Subgroups	Prediction Task
Hu & Rangwala, 2020	Gender, Race	At-Risk (course)
Yu et al., 2020	Gender, Race	College success
Lee & Kizilcec, 2020	Gender, Race	Course grade
Anderson et al., 2019	Gender, Race	Graduation
Kai et al., 2017	Gender, Race	Online college retention
Bridgeman et al., 2009, 2012	Gender, Nationality	Essay scoring
Ogan et al., 2015	Nationality	Learning Outcome

Kizilcec, R. F., & Lee, H. (2020). Algorithmic Fairness in Education.
Baker, R. S., & Hawn, A. (2021). Algorithmic Bias in Education.

Need to Move Upstream

No matter what P looks like…

…and for any reasonable H…

…if we have **enough data** S…

…then for **every h ∈ H**, we have

minimizing error on **data**

$\approx$

minimizing **true/future** error

DETECTOR

What upstream sources shape data collection, modeling, and adaptive decision making?

Are they context aware?

Karumbaiah, S., & Brooks, J. (2021) How Colonial Continuities Underlie Algorithmic Injustices in Education. [IEEE RESPECT21]

Upstream Sources of Bias

Focus on Data Collection Method, System Design, and Theory

No matter what P looks like…

…and for any reasonable H…

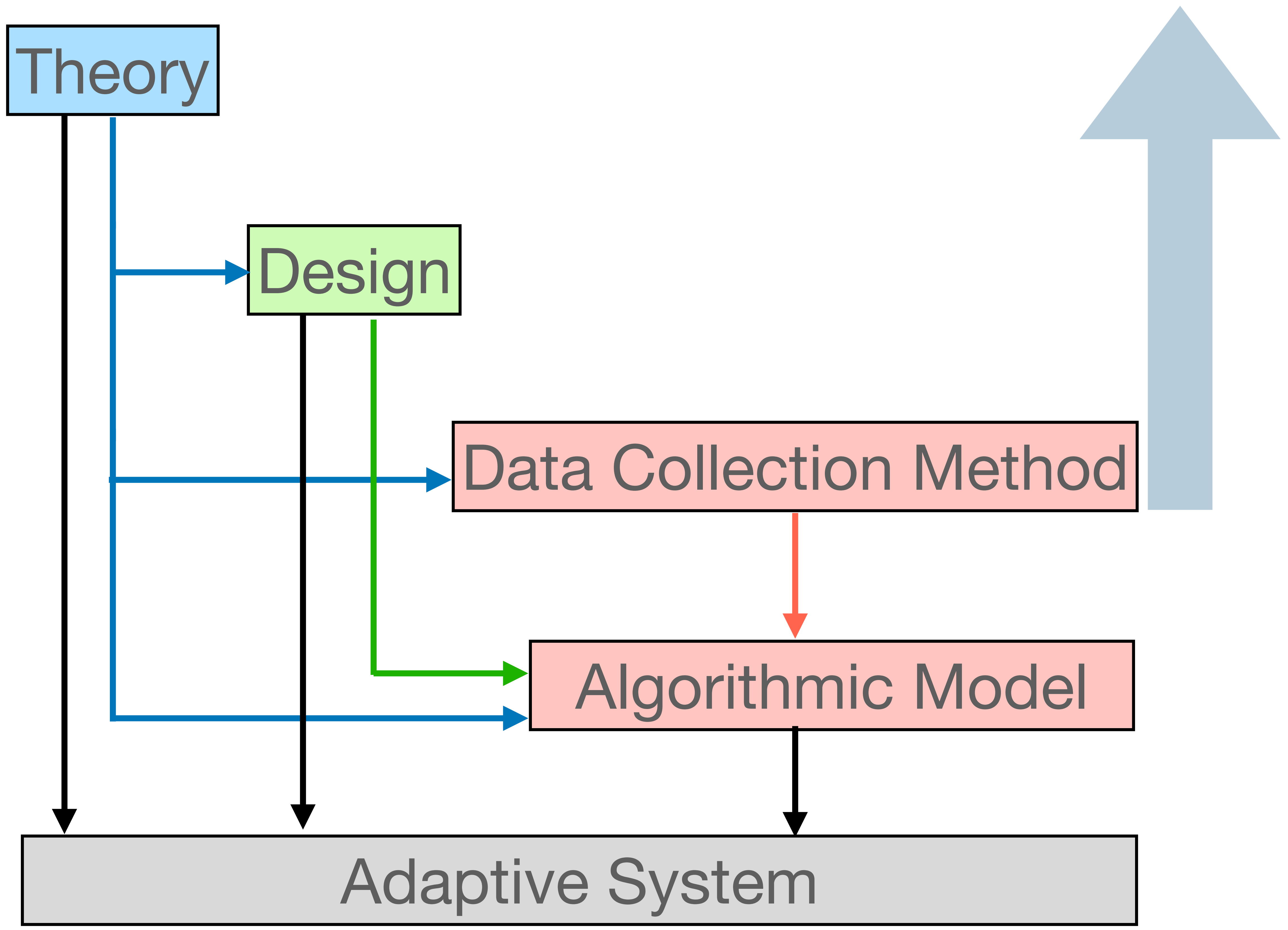
…if we have **enough data** S…

…then for **every h $\in$ H**, we have

minimizing error on **data**

$\approx$

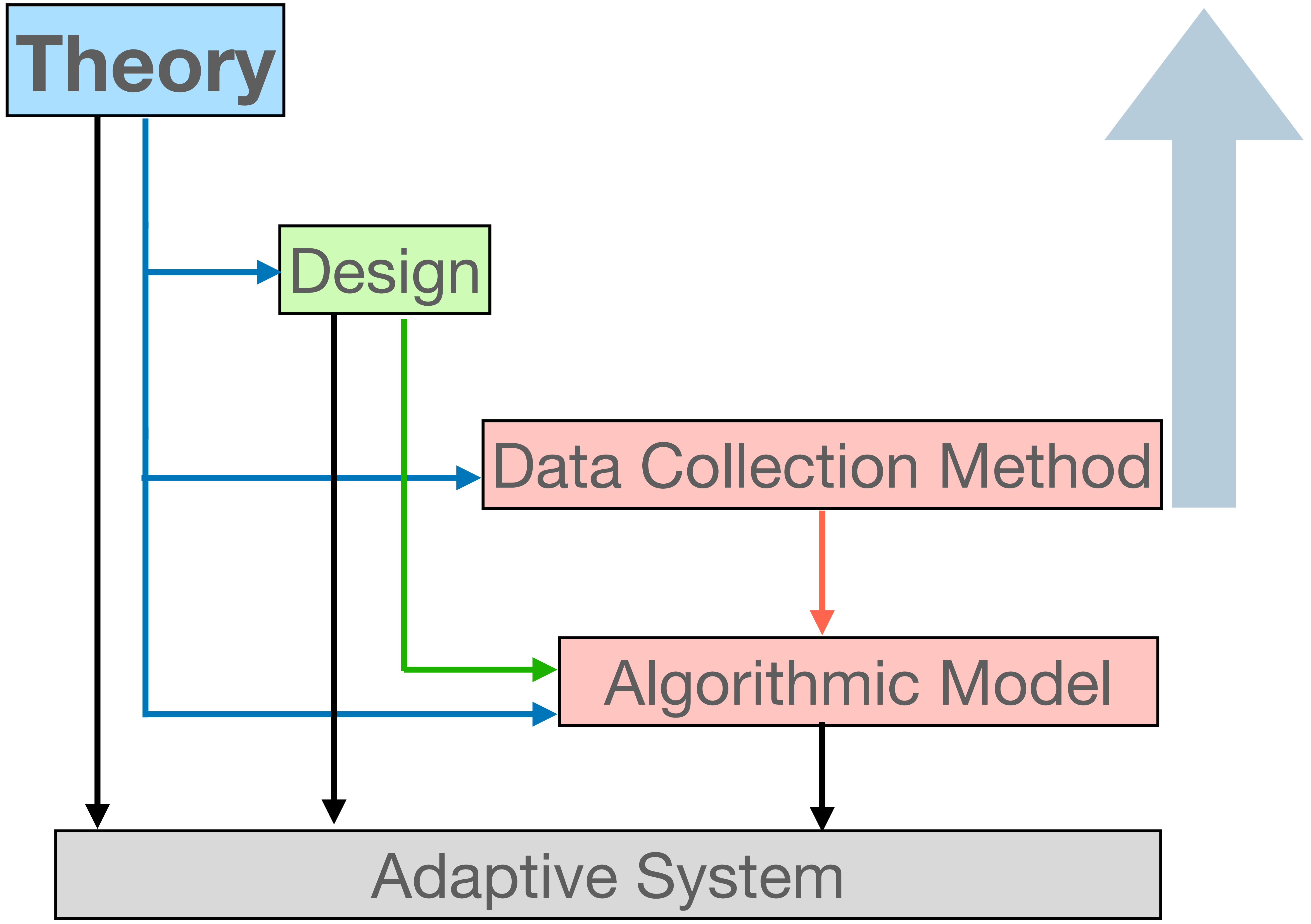
minimizing **true/future** error



Upstream Sources of Bias

Focus on Data Collection Method, System Design, and Theory

- Assumptions around the conceptualization of the construct
- Interpretation of student behaviors in the data collected
- Construction of variables used in predictive modeling
- Design of interventions in adaptive systems

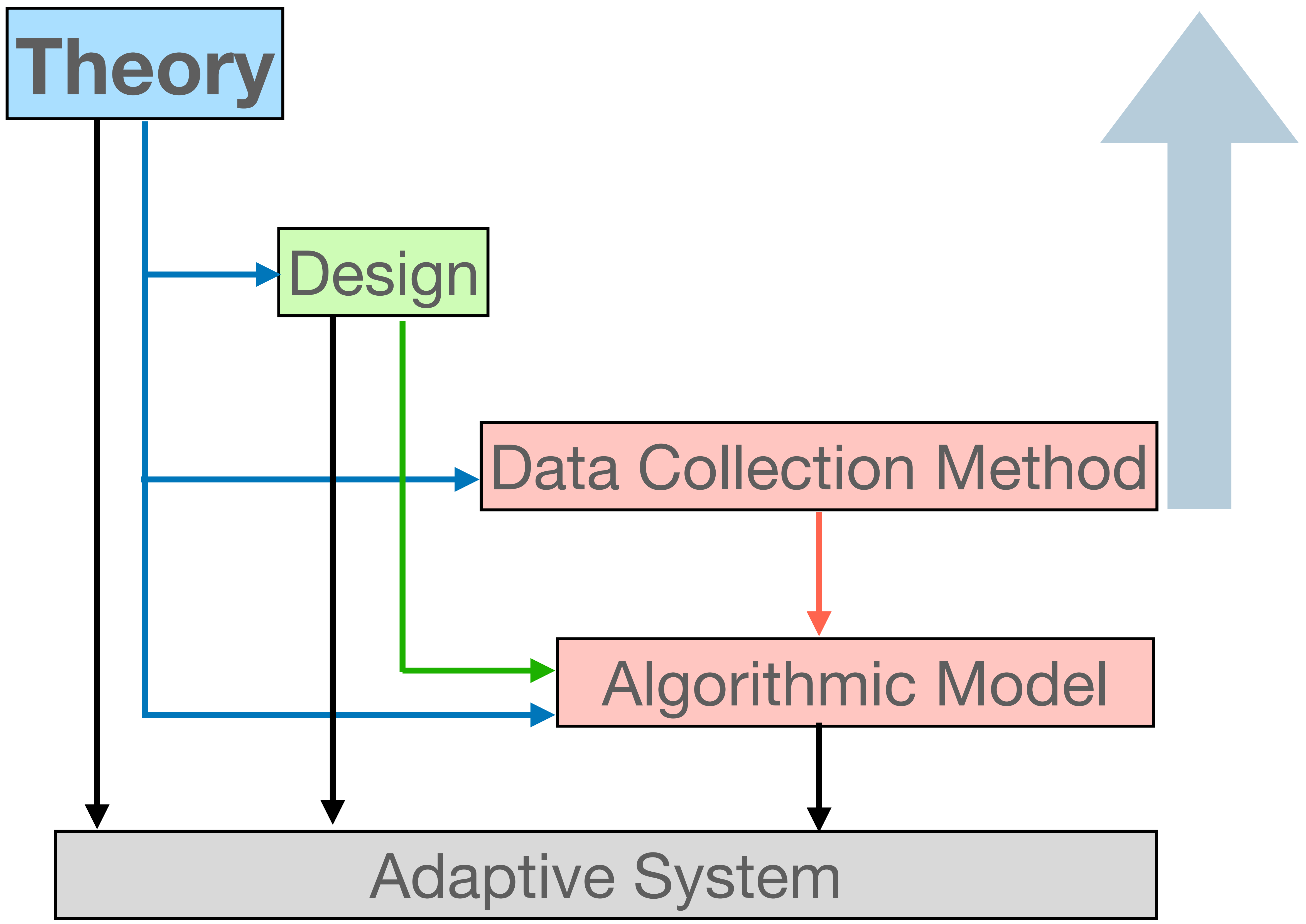


Wise, A. F., & Shaffer, D. W. (2015). Why theory matters more than ever in the age of big data. Journal of Learning Analytics.

Upstream Sources of Bias

Focus on Data Collection Method, System Design, and Theory

- Theory -> Design (e.g., culturally irrelevant rewards as extrinsic motivators)
- Theory -> Data Collection (e.g., choice of culturally irrelevant affective states to collect data for)
- Theory -> System (e.g., theory-driven rules of affective interventions that are culturally insensitive)
- Theory -> Algorithmic model (e.g., influencing a biased choice of predictors for boredom detection)



Sources of Bias

Focus on Data Collection Method, System Design, and Theory

For your example model, name some potential sources of bias (upstream or downstream). Try to be as specific as you can.

Discussion Board Question