Value-Based Prioritization*

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Abstract

A method is proposed to use value theory to quantitatively prioritize potential actions to accomplish a goal. This method is applied to the example of choosing meaningful work using an example value system based on the desire to reduce suffering.

1 Introduction

Why should a particular goal be pursued ("Why")? Given a goal, what actions should be pursued to best accomplish said goal ("What")? Given an action, how should said action be pursued ("How")?

This article proposes that value theory usually best scopes "Why" and "What" and the scientific method usually best answers "How". A method called Value-Based Prioritization is developed to answer the "What" question:

Why: *Value Theory*

↓

What: ***Value-Based Prioritization***

↓

How: *Scientific Method*

2 Why a Goal?

"Why a Goal?" is usually best scoped using value systems because they are evaluative by nature[19]. Evaluating different value systems is left as an (lifelong) exercise for the reader[i].

3 What Actions?

"What Actions?" is usually best scoped by prioritizing actions because actions usually have differing effect sizes and time is limited. It follows from the value system used to answer "Why" that the same value system is used primarily to evaluate the priority of each action.

This article proposes a method called Value-Based Prioritization which builds a quantitative prioritization model based on predicted effect sizes. Raw prioritization scores are further scaled by contextual factors such as implementation time, cost, risk, and other judgments.

4 How to do an Action?

Given answers to "Why?" and "What?", how to implement actions is usually best answered with the scientific method[1]: observations are made and rational thought is used to generate hypotheses, hypotheses are tested with experiments, and successful experiments lead to theories and results.

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*https://github.com/freeradical13/ValueBasedPrioritization

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[i]Example value systems include intuitionism[9], consequentialism[20], evolutionary biology[7], religion[8], epicureanism[12], stoicism[3], political liberalism[25], anarcho-capitalism[10], communitarianism[4], objectivism[2], etc.

5 Value-Based Prioritization

A **value system** V (1) generates a **goal** $G(t)$ (2) (for some future time t) and a set of **mutually exclusive potential future actions** $A(t)$:

$$A(t) = \{A_1(t), \ldots, A_N(t)\}, \quad N > 1 \tag{3}$$

An action's **estimated relative accomplishment amount** $B(A(t))$ is an action's expected *relative* (i.e. with respect to other actions) contribution towards accomplishing G(t):

$$B(A(t)) = \mathbb{R}, \quad 0 \leq \mathbb{R} \leq 1 \tag{4}$$

Thus, $G(t)$ is fully accomplished if all actions are accomplished:

$$G(t) = \sum_{i=1}^{N} B(A_i(t)) = 1 \tag{5}$$

A **value-based prioritization score** $C(A(t))$ is the result of the product of a set of **value-based prioritization scale functions** $S = \{S_1, \ldots, S_N\}$ (6) multiplied by (4):

$$C(A(t)) = B(A(t)) \cdot \prod_{j=1}^{N} S_j(A(t)), \quad 0 \leq S_j(B(A(t))) \leq 1 \tag{7}$$

Example scale functions include implementation time, cost, risk, and other judgments. Ideally, scale functions should be defined before running the model to reduce bias. The set S always includes the element $S_1(A(t)) = 1$. Note that $\sum_{i=1}^{N} C(A_i(t)) \neq G$ if any $S_j(A_i(t)) < 1$.

A **value-based prioritization** $Z(t)$ is a sequence of actions ordered by prioritization score (7) in descending order:

$$Z(t) = (A_1(t), \ldots, A_N(t)), \quad C(A_1(t)) \geq \ldots \geq C(A_N(t)) \tag{8}$$

The first k actions in $Z(t)$ should be executed in descending priority/proportion where k (9) is chosen based on factors such as available concurrency, time, resources, etc.

6 Modeled Value-Based Prioritization

Historical data may be used to predict actions' estimated relative accomplishment amounts (4) at a future time t_F (10) (e.g. the average time actions will take to ramp up implementation).

If each action has historical data $D(A)$:

$$D(A) = ((t_1, D(A, t_1)), \ldots, (t_N, D(A, t_N))) \tag{11}$$

Then, a set of **comparable prediction models** $R(D(A))$ is applied to each $D(A)$ (e.g. exponential smoothing[11,ii], ARIMA[11,iii], linear regression[11,iv], machine learning[13], seasonal algorithms such as TBATS[11,v], poisson regression, etc.):

$$R(D(A)) = \{R_1(D(A)), \ldots, R_N(D(A))\} \tag{12}$$

The models are compared using **model selection** (or forecasting)[11,21,26,28,vi] using a model selection algorithm $L(R(D(A)))$ (13) (e.g. smallest Akaike's Information Criterion [AIC], smallest Corrected AIC [AICc], smallest Bayesian Information Criterion [BIC], smallest cross-validation, largest adjusted coefficient of determination [$\bar{R}^2$], etc.).

For each action, $L(R(D(A)))$ produces the **best fitting model** $M(A(t))$ (or a model that's an average of multiple models[6,vii]).

Each action's $M(A(t_F))$ is used to predict $B(A(t_F))$.

Finally, **modeled value-based prioritization** $Z(t_F)$ (14) is simply (8) with t_F.

[ii] https://otexts.com/fpp2/expsmooth.html
[iii] https://otexts.com/fpp2/arima.html
[iv] https://otexts.com/fpp2/regression.html
[v] https://otexts.com/fpp2/advanced.html
[vi] https://otexts.com/fpp2/selecting-predictors.html
[vii] https://otexts.com/fpp2/combinations.html

7 Choosing Meaningful Work

The following example applies modeled value-based prioritization (14) to the goal of choosing meaningful work[14]. Every aspect is an example and should be reconsidered.

First, outline the parameters:

- (1) V = a value system which answers "Why work?" with "To reduce suffering" which is defined as maximal human suffering: death[viii]. Alternatives include morbidity and disease burden (e.g. Quality-Adjusted Life Years [QALYs][24]), non-human suffering, pre-birth suffering, etc.
- (2) $G(t)$ = eliminate human death.
- (3) $A(t)$ = the set of actions which would eliminate human death.
- (9) $k = 1$ for a single person (use 2 to hedge the failure of the first action or as a volunteer activity).
- (10) $t_F = 10$ years; an average amount of time under normal conditions to integrate into a new career to work on some subset of $A(t)$ (including learning, certification, building experience, networking, etc.).
- (11) $D(A)$ = time-series data on human death by underlying cause[ix].
- (12) $R(D(A))$ = exponential smoothing functions using Holt's linear trend method[x,xi,xii]:

$$\{ETS(A, A, N), ETS(A, A_d, N),\\ ETS(A, M, N), ETS(A, M_d, N)\},\\ \phi = 0.98$$

Commonly used alternative models include poisson log-bilinear regressions:

"There is a substantial literature on the projection or forecasting of all-cause mortality rates and mortality rates for specific diseases. The methods used fall into two broad groups. First are those methods based on time-series analysis of historical trends in mortality rates. These 'aggregate models,' whether for all-cause mortality or for specific causes, use the previous trend of the variable of interest as the basis for predicting its future value. By their data requirements, such methods are generally limited to high-income countries with good death registration data [...]. Second are the 'structural models,' which are based on relationships between mortality and a set of independent variables, and are necessarily projections of those independent variables. To the extent that the structural model identifies the important components — and the relationships among them — of the 'system' that determines the variable of interest, they offer the potential for more robust predictions. When the underlying system is complex and sensitive to one or more of its components, a shift in some of the system variables can introduce large changes in the outcome that may be missed by extrapolation (such as the discovery of antibiotics and infectious disease trends or the change in tuberculosis mortality after the HIV epidemic). Aggregate models, in contrast, require considerably less knowledge of the system components and the relationships among them. These models can therefore provide more reliable estimates when such information is not available, especially when the system is not very sensitive to its inputs in time intervals that are in the order of the prediction time."[15]

- (13) $L(R(D(A)))$ = lowest AICc.

$A(t)$ is a set of actions which would elimi-

[viii] More accurately, something like the lack of a potential of life.

[ix] https://www.who.int/topics/mortality/en/

[x] https://otexts.com/fpp2/holt.html

[xi] https://otexts.com/fpp2/ets.html

[xii] https://www.statsmodels.org/dev/examples/notebooks/generated/exponential_smoothing.html

nate the groups of underlying causes of death in the United States. This example starts by looking at the ICD-10[16–18,xiii] 113 Selected Causes of Death list[5,22,23,27,xiv,xv,xvi,xvii]:

$$A(t) = \{$$
$$A_1(t) = \text{Eliminate: Malignant neoplasms},$$
$$A_2(t) = \text{Eliminate: Ischaemic heart diseases},$$
$$\ldots$$
$$A_{179}(t) = \text{Eliminate: Other disorders of ear}$$
$$\}$$

Review the list of actions[xviii] and hypothesize scale functions. Examples:

- $S_1(A_i) = 1$

  Required scale function.

- $S_2(A_i) = \left(1 - \frac{AverageAge(A_i(t_{max-5}:t_{max}))}{MaxAge(A(t))}\right)$

  Scale towards younger people because they have more to lose: one minus the ratio of the average age over the last 5 years compared to the maximum age of all deaths.

- $S_3(A_i) = \left(\frac{(f(A_i) - min(f(A(t)))) \cdot (b-a)}{max(f(A(t)) - min(f(A(t))}\right) + a,$

  $f(A_i) = M'(A_i(t_F)), a = 0.5, b = 1$

  Scale down by up to half by the relative rate of change of an action's predicted rate of death: Take the derivative of $M(A_i(t))$ and evaluate it with the predicted value and min-max normalize[xix] into $[0.5, 1]$ relative to other actions.

- $S_4(A_i) = \begin{cases} 0.1 & \text{if political/cultural} \\ 1 & \text{otherwise} \end{cases}$

  Essentially remove actions that are primarily political and/or cultural.

The list does not include common scale functions such as implementation time, cost, risk, playing into strengths, piquing interest, market demand, return on investment, ramp-up time, interest, etc. because all medical actions are predicted to be in the same order of magnitude for those scales and all other actions are primarily political so they have a low score, rendering those scales moot.

Create a table listing all actions as rows and all *manually calculated* scale functions as columns[xx,xxi]:

Action	S_1	...	S_N
A_1	0.1		1
A_2	1		0.25
...			
A_N	0.99		0.9

Table 1: Theoretical scale function table

For example:

Action	S_4
Eliminate: Assault	0.1
Eliminate: Legal intervention ...	0.1
Eliminate: Malnutrition	0.1
Eliminate: Transport accidents	0.1

Table 2: Example scale function table

[xiii] For a discussion of chapters, sub-chapters, and codes, see pages 13-17 of ICD-10 Volume 2[16]. For a discussion of the definition of underlying cause of death, see page 31 of ICD-10 Volume 2[16].

[xiv] https://wonder.cdc.gov/wonder/help/ucd.html#ICD-10%20113%20Cause%20List

[xv] Group Results By "Year" And By "ICD-10 113 Cause List"; Check "Export Results"; Uncheck "Show Totals"

[xvi] https://www.cdc.gov/nchs/data/dvs/Multiple_Cause_Record_Layout_2016.pdf, page 19; The list actually has 115 mutually exclusive groups instead of 113.

[xvii] `python3 -m vbp.run count UnderlyingCausesOfDeathUnitedStates`

[xviii] `python3 -m vbp.run list UnderlyingCausesOfDeathUnitedStates`

[xix] https://en.wikipedia.org/wiki/Normalization_(statistics)

[xx] For the example scale functions, this is only $S_4(A_i)$.

[xxi] `python3 -m vbp.run manual_scale_functions -t excel -o manual_scale_functions.xlsx -n "Scale Values" -p "Eliminate:  " UnderlyingCausesOfDeathUnitedStates S4`

Outside of the manually calculated scale function table, use obfuscated action names when developing the model to avoid introducing bias.

$D(A)$ for each action is the time-series data of number of deaths per year per 100,000 of population ("Crude Rate")[xxii]. For example, for *Malignant neoplasms*[xxiii]:

Year	Crude Rate
1999	197.0
...	...
2017	183.9

Table 3: Crude rate of deaths per year for *Malignant neoplasms*

Run each comparable prediction model $R_i(D(A))$. For example, for *Malignant neoplasms*[xxiv]:

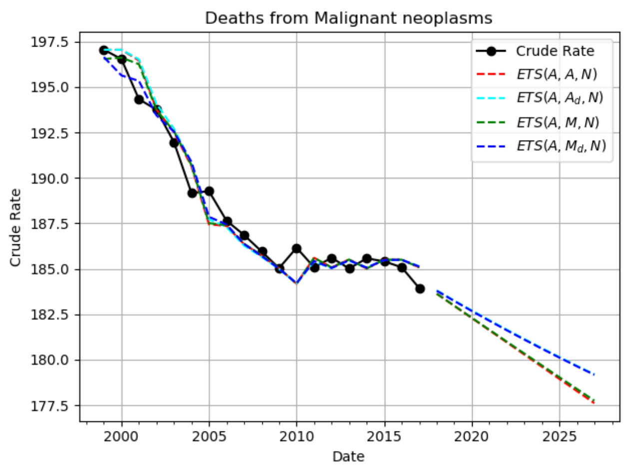

Figure 1: Exponential smoothing functions $ETS(A, *, N), \phi = 0.98$ using Holt's linear trend method for *Malignant neoplasms*

Scedasticity, forecast uncertainty, and outliers are not considered because it's not clear how to automate processing of such data to tune or choose models.

For each model, calculate AICc and choose the model $M(A(t_F))$ that has the lowest AICc. For example:

$R_i(D(A))$	AICc	Predicted
$ETS(A, A, N)$	13.43	177.60
$ETS(A, A_d, N)$	18.78	179.19
$\boldsymbol{ETS(A, M, N)}$	**12.44**	**177.75**
$ETS(A, M_d, N)$	14.35	179.17

Table 4: Example AICc values of $R_i(D(A))$ for *Malignant neoplasms*

Use each $M(A(t_F))$ to calculate the predicted value and then generate all of the relative $B(t_F)$ values (setting negative values to 0) and any scale functions based on the models (e.g. scaling by the relative prediction derivatives using S_3). For example:

Action	$B(t_F)$	S_1	S_3
Action1	0.17	1.0	0.57
Action2	0.09	1.0	1
...	...	...	...

Table 5: Example $B(t_F)$ values and model-based scale function values

Combine the table above with the manually calculated scale functions table 1 and any other calculated scale functions (e.g. $S_2(A_i)$) to create the final table with all scale function values. For example:

Action	$B(t_F)$	S_1	S_2	S_3	S_4
Action1	0.17	1.0	0.39	0.57	1
Action2	0.09	1.0	0.62	1	1
...	...	...	...	...	

Table 6: Example $B(t_F)$ values with all scale function values

Calculate the product of each action's $B(t_F)$ and its scale function values to produce

[xxii] https://wonder.cdc.gov/wonder/help/cmf.html#Frequently%20Asked%20Questions%20about%20Death%20Rates

[xxiii] `python3 -m vbp.run action_data UnderlyingCausesOfDeathUnitedStates "Malignant neoplasms"`

[xxiv] `python3 -m vbp.run predict UnderlyingCausesOfDeathUnitedStates --do-not-obfuscate -p 10 "Malignant neoplasms"`

the final $Z(t_F)$ table and then sort by the values in descending order and choose the top k actions. For the parameters and data in this example, the result is[xxv]:

k	Action	$Z(t_F)$
1	Eliminate: TODO	0.08

Table 7: Example $Z(t_F)$ table

8 Discussion

"Substantial research remains to develop robust and unbiased methods for measuring trends in case fatality rates, survival times, and disability due to specific causes, let alone collecting such data across all regions of the world. Despite these uncertainties, projections provide a useful perspective on population health trends and health policies, provided that they are interpreted with a degree of caution. Projections enable us to appreciate better the implications for health and health policy of currently observed trends, and the likely impact of fairly certain future trends, such as the ageing of the population, and the continuation of the epidemiological transition in developing countries." [15]

[xxv] `python3 -m vbp.run modeled_value_based_prioritization UnderlyingCausesOfDeathUnitedStates -p 10 --manual-scales manual_scale_functions.xlsx --average-ages S2 --average-age-range 5`

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9 Appendix

TODO