STRAIN
Sacks, Tackles, Rushing, Aggression INdex

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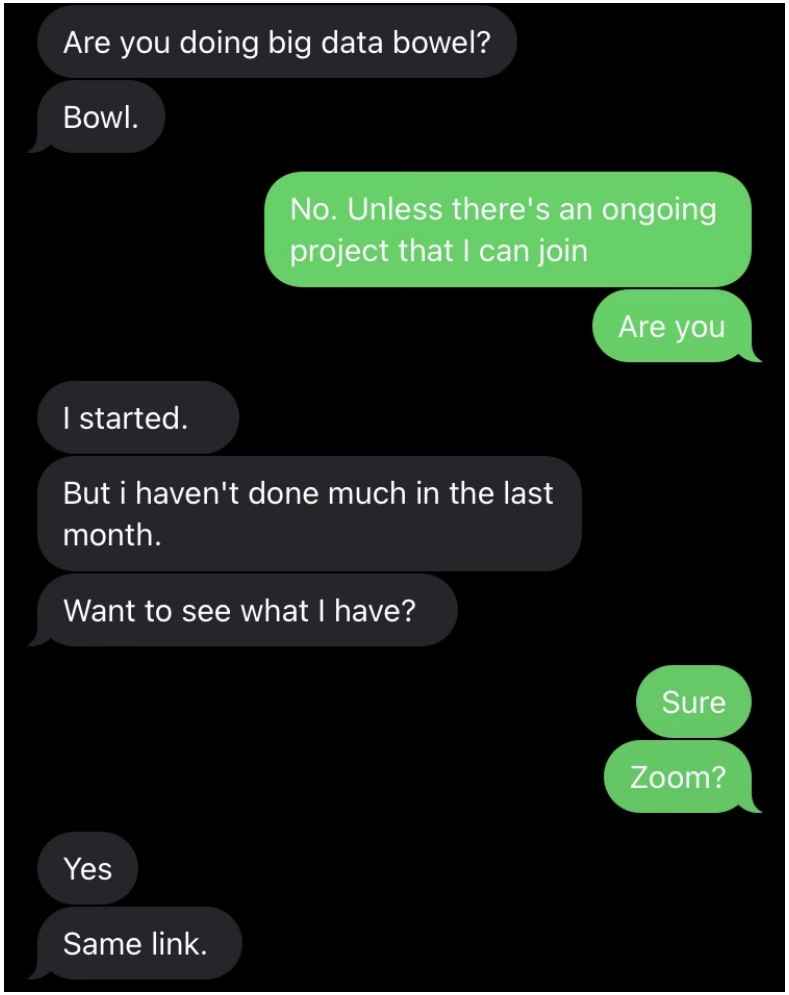
ACKNOWLEDGEMENTS

Gregory Matthews
Loyola University Chicago

"My holy grail of football metrics is a good way to measure offensive linemen."

"I say we just add a bunch of stuff and then prune. Like a CART model."

HOW IT STARTED



BIG DATA BOWL 2023

Ron's #CMSAC22 workshop slides

stat.cmu.edu/cmsac/conference/2022/workshop/slides.html

BACKGROUND

- Limitations of previous metrics
  - Sacks, hits, hurries
  - Time in pocket (TIP)
  - Pass rusher/blocker win rate (PRWR, PBWR)

MOTIVATION

How do we measure pass rusher effectiveness?

- Distance to QB
- Moving rate towards QB
- How about both?

https://wikipedia.org/wiki/Inverse_second

STRAIN RATE IN MATERIALS SCIENCE

- Strain: deformation of a material from stress.

$$s(t) = \frac{L(t) - L_0}{L_0}$$

- Strain rate

$$s'(t) = \frac{ds}{dt} = \frac{v(t)}{L_0}$$

$L(t)$: distance between two points of interest at time t

L_0: initial distance between those two points

$v(t)$: how fast two points of interest are moving away from/towards each other

AN ANALOGY

- A pass-rusher tries to apply force/deformation against the offensive line with the ultimate goal of breaking through the protection to reach the QB.
- Players = "particles" in some material
    - The defensive "particles" are attempting to exert pressure on the pocket with the aim of compressing and collapsing this pocket around the QB.

APPLICATION TO PASS-RUSH

Definition (STRAIN). Let (x_{ijt}, y_{ijt}) be the (x, y) location on the field of player $j = 1, \cdots, J$ at frame $t = 1, \cdots, T_i$ for play $i = 1, \cdots, n$; and $(x_{it}^{QB}, y_{it}^{QB})$ be the (x, y) location of the QB at frame t during play i.

- Distance between player j and QB at frame t during play i

$$f_{d_{ij}}(t) = \sqrt{(x_{ijt} - x_{it}^{QB})^2 + (y_{ijt} - y_{it}^{QB})^2}$$

- Rate at which player j is moving towards QB at frame t during play i

$$f'_{d_{ij}}(t) = \frac{df_{d_{ij}}(t)}{dt}$$

- STRAIN for player j at frame t during play i

$$\text{STRAIN}_{ij}(t) = \frac{-f'_{d_{ij}}(t)}{f_{d_{ij}}(t)}$$

APPLICATION TO PASS-RUSH (CONT'D)

- STRAIN estimate

$$\widehat{\text{STRAIN}}_{ij}(t) = \frac{-\frac{f_{d_{ij}}(t) - f_{d_{ij}}(t-1)}{0.1}}{f_{d_{ij}}(t)}.$$

- Let's break it down...

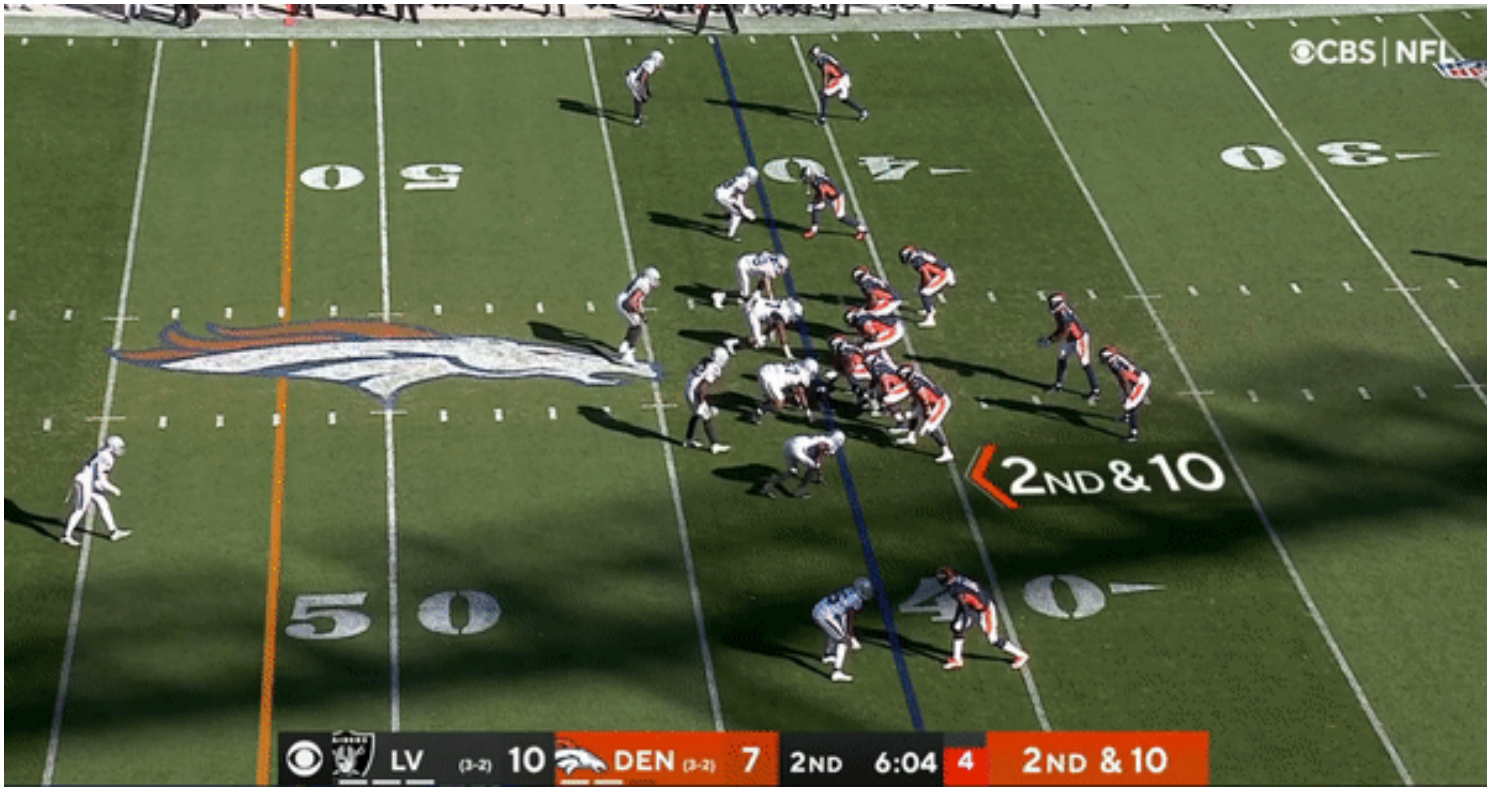
ADVANTAGES OF STRAIN

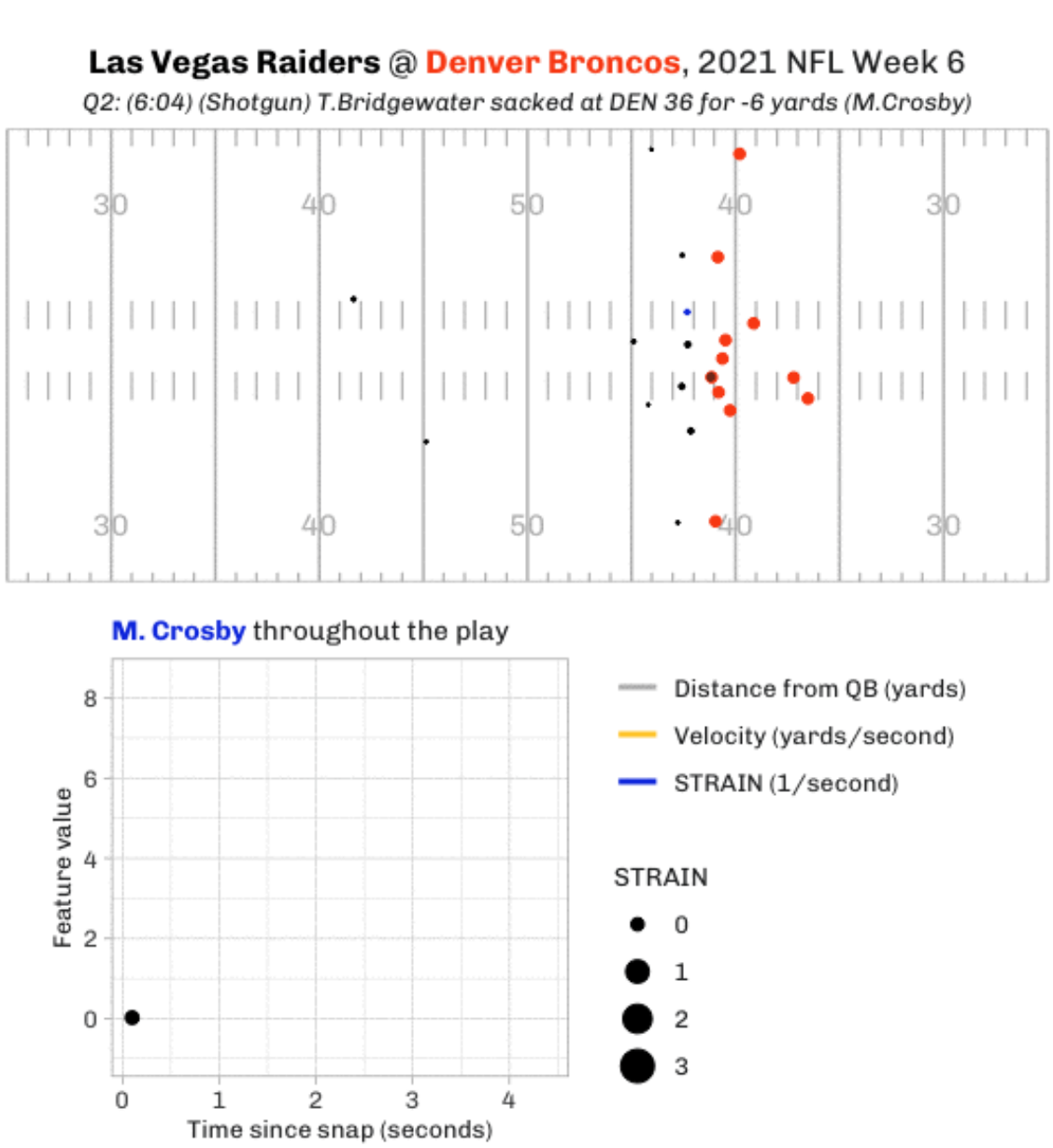
- Simple
- Interpretable
- Derived from a well-established concept from another field
- Continuous-time within-play metric

DATA PREP

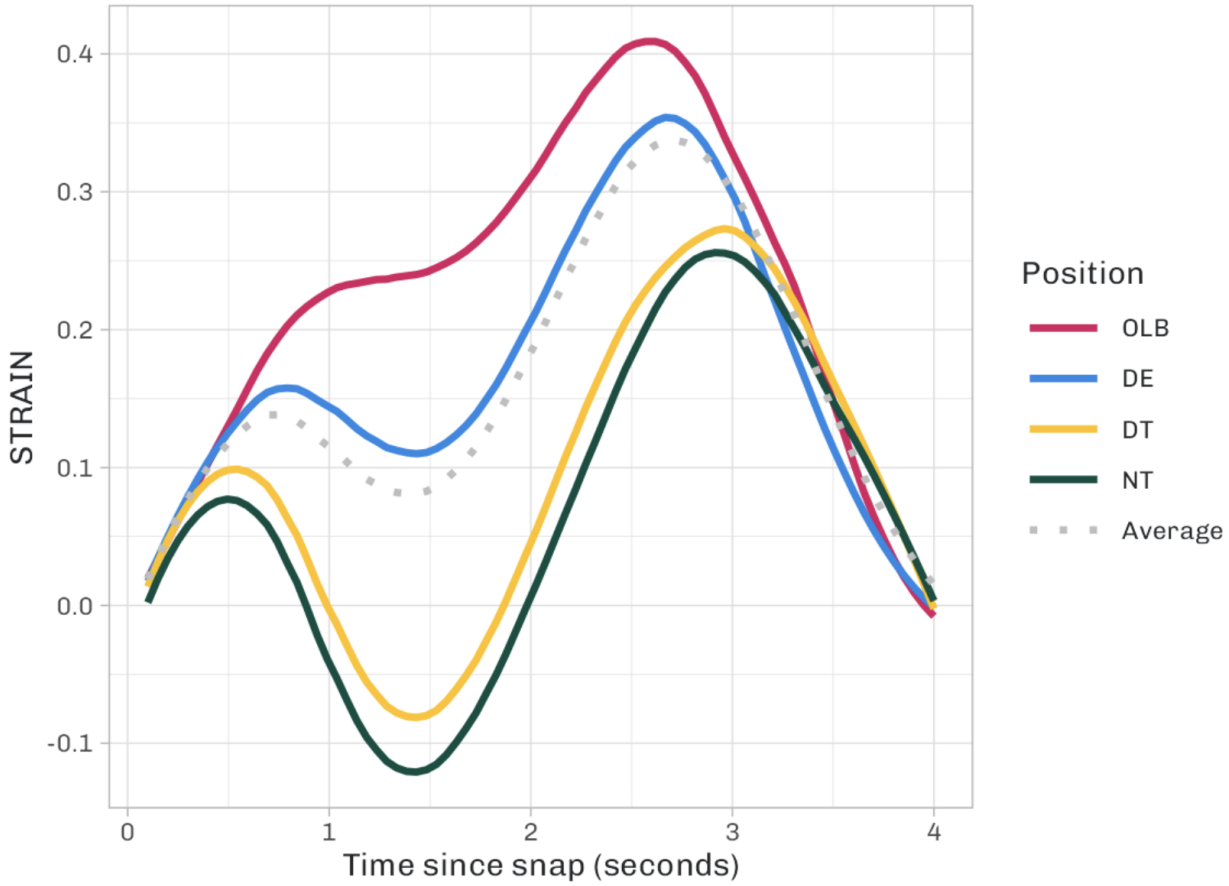
- Frames between snap and pass forward/QB sack
- Remove plays with multiple QBs (e.g. no Taysom Hill)
- PFF scouting data, "Pass rush" role

EXAMPLE PLAY




Las Vegas Raiders @ Denver Broncos, 2021 NFL Week 6
Q2: (6:04) (Shotgun) T.Bridgewater sacked at DEN 36 for -6 yards (M.Crosby)
30
40
50
40
30
30
40
50
40
30
M. Crosby throughout the play
Feature value
8
6
4
2
0
0
1
2
3
4
Time since snap (seconds)
Distance from QB (yards)
Velocity (yards/second)
STRAIN (1/second)
STRAIN
0
1
2
3

POSITIONAL STRAIN CURVES



https://en.wikipedia.org/wiki/Edge_rusher

RANKING THE BEST PASS RUSHERS

Top 20 Edge Rushers
(Minimum 100 plays)

Rank	Player	Team	Position	Total Plays	STRAIN[1]
1	Rashan Gary	GB	OLB	176	2.82
2	Leonard Floyd	LA	OLB	185	2.80
3	Justin Houston	BAL	OLB	132	2.78
4	Myles Garrett	CLE	DE	197	2.75
5	Von Miller	DEN	OLB	145	2.75
6	T.J. Watt	PIT	OLB	147	2.71
7	Yannick Ngakoue	LV	DE	175	2.70
8	Alex Highsmith	PIT	OLB	129	2.65
9	Preston Smith	GB	OLB	124	2.61
10	Randy Gregory	DAL	DE	134	2.58
11	Joey Bosa	LAC	OLB	160	2.58
12	Darrell Taylor	SEA	DE	107	2.57
13	Josh Sweat	PHI	DE	159	2.57
14	Maxx Crosby	LV	DE	198	2.56
15	Markus Golden	ARI	OLB	164	2.50
16	Khalil Mack	CHI	OLB	132	2.50
17	Derek Barnett	PHI	DE	147	2.49
18	Trey Hendrickson	CIN	DE	197	2.44
19	Nick Bosa	SF	DE	148	2.43
20	Bryce Huff	NYJ	DE	131	2.43

[1] Average STRAIN across all frames played

Top 20 Interior Rushers
(Minimum 100 plays)

Rank	Player	Team	Position	Total Plays	STRAIN[1]
1	Aaron Donald	LA	DT	239	1.67
2	Solomon Thomas	LV	DT	115	1.51
3	Quinton Jefferson	LV	DT	144	1.46
4	Chris Jones	KC	DT	139	1.42
5	DeForest Buckner	IND	DT	198	1.26
6	Cameron Heyward	PIT	DT	188	1.25
7	Javon Hargrave	PHI	DT	156	1.24
8	Jerry Tillery	LAC	DT	171	1.16
9	Ed Oliver	BUF	DT	133	1.15
10	Osa Odighizuwa	DAL	DT	162	1.13
11	Greg Gaines	LA	NT	111	1.11
12	Leonard Williams	NYG	DT	226	1.03
13	Christian Barmore	NE	DT	166	1.02
14	Vita Vea	TB	NT	184	1.01
15	B.J. Hill	CIN	DT	123	0.96
16	Quinnen Williams	NYJ	NT	146	0.96
17	Kenny Clark	GB	NT	211	0.94
18	Angelo Blackson	CHI	DT	106	0.93
19	Malik Jackson	CLE	DT	186	0.92
20	Grady Jarrett	ATL	DT	159	0.92

[1] Average STRAIN across all frames played

FUTURE DIRECTIONS

- What about pass-blocking?
  - Rusher-to-blockers matching
  - https://www.kaggle.com/code/fluberson/blocking-is-a-drag
- "Meta-metrics" (Franks, D'Amour, Cervone & Bornn (2016))
  - Discrimination: Does the metric reliably differentiate between players?
  - Stability: Does the metric measure a quantity that is stable over time?
  - Independence: Does the metric provide new information?
- Correlate STRAIN with previously-established metrics
- Show if STRAIN relates to EPA, completion probability, etc.

FUTURE DIRECTIONS

- Other concepts in materials science/physics
  - Stress: force over an area
  - Elastic modulus: ratio of stress and strain, measures the resitance of an object (the POCKET) to being deformed elastically

CHEERS

- Notebook

kaggle.com/code/statsinthewild/strain-sacks-tackles-rushing-aggression-index

- Code

github.com/qntkhvn/strain