Scouting in *FIRST* Robotics

Novi Kickoff Workshop
January 7th, 2012

Scouting

by

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Outline

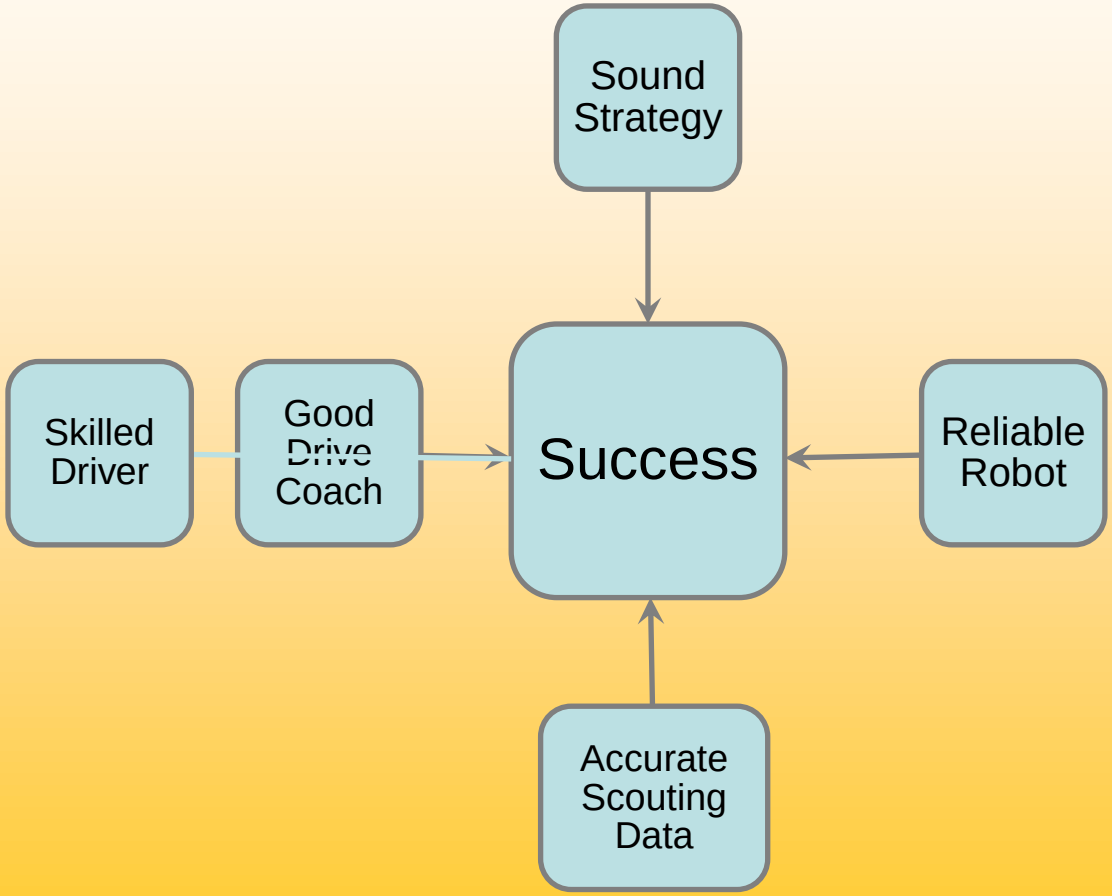
- What is Scouting and why is it important?
- What are the different ways to scout?
- What are the different Scouting positions?

- Quick Tutorial in Matrix Algebra
- Review of a method of ranking teams
- Proposed new method of ranking teams
- Features of the Scouting Database

What is the Purpose of Scouting?

- Find out the strength and weakness of your alliance partners and opponents for each match
- Allow you to adjust your tactics of each match based on that information
- Help to create a pick list for alliance selection

Formula for Robot Success



What are the Different Ways to Scout?

Before your Event:

- ❑ Scout on teams' websites, videos from youtube and theblue alliance.net

At the Event:

- ❑ Pit Scouting (subjective)
- ❑ Match Scouting (subjective and objective)
- ❑ Videotaping each match for analysis and review
- ❑ Calculated Contribution (objective)

Pit Scouting Sheet

Team # _____ Pit Scouting Sheet Team 2834
Initials _____

Chassis

Number of Axles	2 or 3 or 4 or _____
Number of Driven Axles	1 or 2 or 3 or _____
Wheel Type	KOP Rubber, KOP traction, traction web top, OMNI, AM Mecanum, Custom Mecanum, other (axle) 1st_____ 2nd_____ 3rd_____ 4th_____ (axle) 1st_____ 2nd_____ 3rd_____ 4th_____
Articulated Axle	Y / N
Speed?	1st Gear_____ 2nd Gear_____

Tube Handling

Pick up from floor	Y / N			
Pick up from feeder	Y / N			
Ability to Hang **if able to hang on entire level, just circle L/M/H.*	**Low**	Sides	Middle	
	Middle	Sides	Middle	
	High	Sides	Middle	
Manipulator Type:	Arm	Elevator	Other	N/A
Gripper Type:	Claw	Roller	Other	N/A

Minibot

Have a minibot	Y / N
Able to Deploy	Y / N
Time to top, N/A if no time given	_____

Autonomous

Starting Position (circle one)	side	middle	
Ubertube hanging position. **If can't, cross out.*	**Low**	Sides	Middle
	Middle	Sides	Middle
	High	Sides	Middle

Notes:

Match Scouting Sheet

Team 2834 Match Scouting Sheet

Match Number	
Team Number	
Starting Position	center / sides

Last Name: _____

	Autonomous	Teleoperated		End Game
	Number of Ubertubes hung	Number of tubes scored	Total tubes transported across center line	Place of minibot
Top		◯		1 2 3 4
Middle		◯		(5) failed attempt
Bottom		◯	◯	didn't attempt

# of Penalties	# of Pinning Penalties

Notes:

Match Scouting Sheet

Aluminum Falcons Scouting System [AFSS]

FRC 2011 - LogoMotion - Championship

Please Print Clearly And Neatly, This Data Will Be Inputted Into Excel

Input Match Data

Team #		Match #	

Enter Specific Team Name & Specific Match Number Above

Autonomous Starting Position

Outside Left	Middle	Outside Right

Circle The Robot Starting Position For Autonomous

Tube Placement

	"Left Rack"			"Right Rack"			Options
Top [T]							*R*
Middle [M]							*R+U*
Bottom [B]							*W*
							W+U
							B
							B+U
	A	B	C	D	E	F	*U*

Mark Tube Placement By This Robot Only

Minibot Delivery / Endgame

Hostbot		Minibot				
Offense	Defense	1st	2nd	3rd	4th	Did Not Make It
		Time to Climb (s)				

Circle What The Robot Achieved In The Endgame

Robot/Human Player Attributes

Speed of Robot	R	(1) (2) (3)
Defensive/Offensive	R	Offensive / Equal / Defensive
Pick-Up From Ground	R	Y / N
Received Penalties	R	Y / N
Pick-Up From Human Player	R	Y / N
Threw Tubes	H	Y / N
Pushed Tubes Through Wall	H	Y / N
Maneuverability	R	(1) (2) (3)

Please Circle Your Observations Above

Comments

Please Provide Brief Comments On Robot Design & Performance

Pre-Match Sheet

Pre-Match Scouting Sheet

Red Alliance

Red Alliance Member #1

Team Number	Notes:	Drivetrain Type
		4WD
Autonomous Mode(s)		6WD
		8WD
		Omni
		Mecanum
		Crab
		Hybrid

Red Alliance Member #2

Team Number	Notes:	Drivetrain Type
		4WD
Autonomous Mode(s)		6WD
		8WD
		Omni
		Mecanum
		Crab
		Hybrid

Red Alliance Member #3

Team Number	Notes:	Drivetrain Type
		4WD
Autonomous Mode(s)		6WD
		8WD
		Omni
		Mecanum
		Crab
		Hybrid

Blue Alliance

Red Alliance Member #1

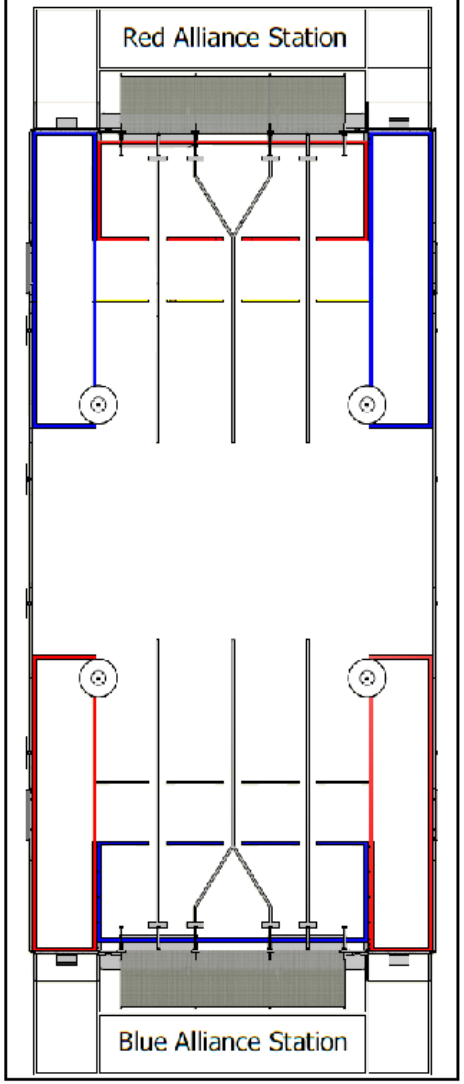
Team Number	Notes:	Drivetrain Type
		4WD
Autonomous Mode(s)		6WD
		8WD
		Omni
		Mecanum
		Crab
		Hybrid

Blue Alliance Member #2

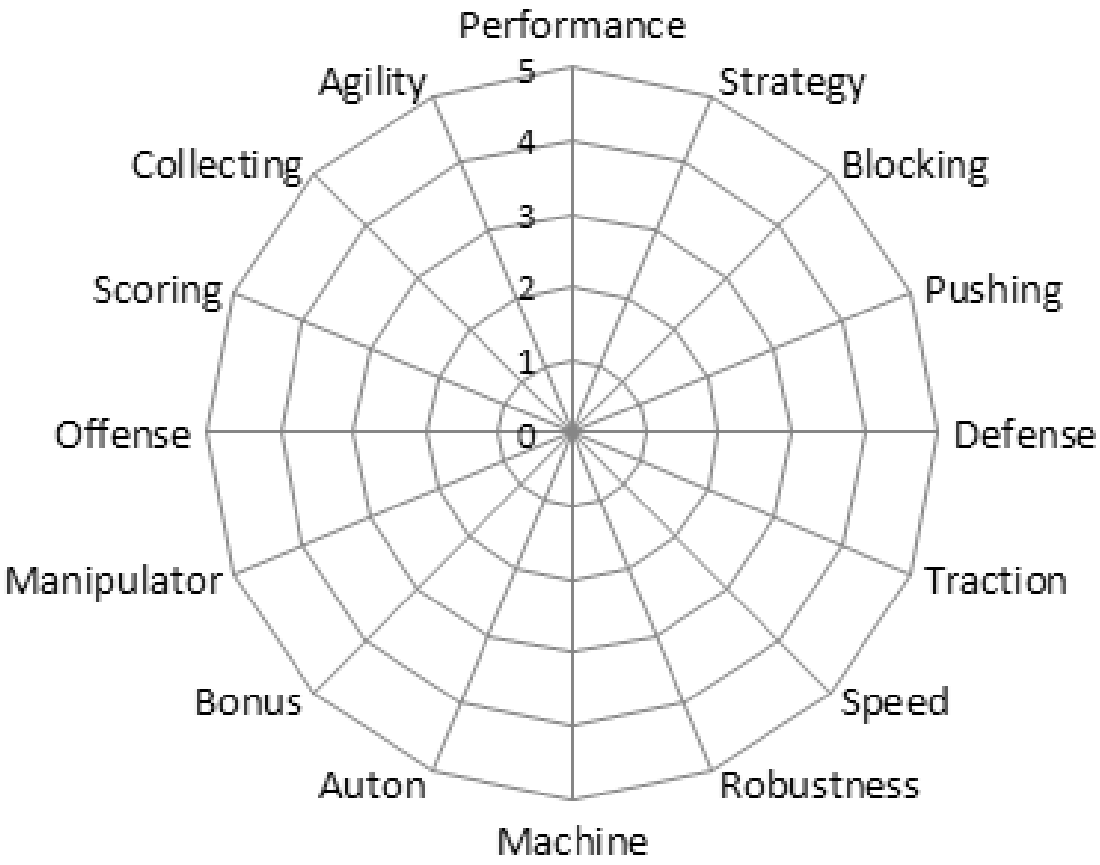
Team Number	Notes:	Drivetrain Type
		4WD
Autonomous Mode(s)		6WD
		8WD
		Omni
		Mecanum
		Crab
		Hybrid

Blue Alliance Member #3

Team Number	Notes:	Drivetrain Type
		4WD
Autonomous Mode(s)		6WD
		8WD
		Omni
		Mecanum
		Crab
		Hybrid



Pre-Match Sheet



Pre-Match Sheet

MichiganState
setup link

Match 128

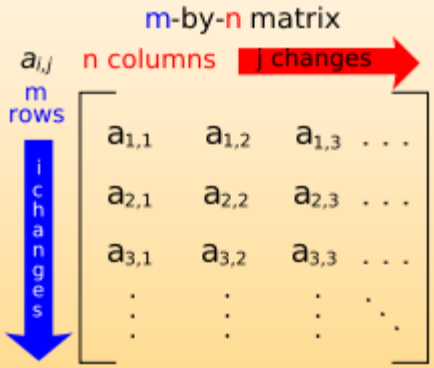
Red Alliance							Blue Alliance						
					projected score								
					2	7							
Red 1	2834	Projected OPR	1.7	Proj. CCWM	-0.6		548	Projected OPR	1.0	Proj. CCWM	0.6		Blue 1
		Current OPR	2.1	Avg Seed Score	2.1			Current OPR	1.8	Avg Seed Score	2.3		
				auto % handled	57%					auto % handled	40%		
		robot speed	1.8182	auto % scored	43%			robot speed	1.6364	auto % scored	4%		
		cross zone	1	tele ball handle	5.0909			cross zone	1	tele ball handle	2.0909		
				tele ball scored	4.1818					tele ball scored	0.7273		
		ball control	1.1818	finale ball handl	1.0909			ball control	1.7273	finale ball handl	0.1818		
		avg ball handle	6.1818	finale ball score	1			avg ball handle	2.2727	finale ball score	0.1818		
				elevate/suspen	0					elevate/suspen	0		
		start zone	1.2727	# of penalties	0			start zone	2.2727	# of penalties	0		
	Auton:				0		Auton:				0		
	Finale:				0		Finale:				0		
Red 2	3115	Projected OPR	0.4	Proj. CCWM	-0.7		2960	Projected OPR	0.2	Proj. CCWM	-0.7		Blue 2
		Current OPR	1.9	Avg Seed Score	2.2			Current OPR	0.8	Avg Seed Score	2.4		
				auto % handled	58%					auto % handled	43%		
		robot speed	1.9091	auto % scored	26%			robot speed	1.9	auto % scored	29%		
		cross zone	1.2857	tele ball handle	1.7273			cross zone	1	tele ball handle	3.1818		
				tele ball scored	1.2727					tele ball scored	2.7273		
		ball control	1.6364	finale ball handl	0.0909			ball control	1.8	finale ball handl	0.1818		
		avg ball handle	1.8182	finale ball score	0.0909			avg ball handle	3.3636	finale ball score	0.1818		
				elevate/suspen	0					elevate/suspen	0		
		start zone	1.7273	# of penalties	0.0909			start zone	1.2727	# of penalties	0.0909		
	Auton:				0		Auton:				0		
	Finale:				0		Finale:				0		
Red 3	815	Projected OPR	1.2	Proj. CCWM	-0.6		66	Projected OPR	0.7	Proj. CCWM	-0.3		Blue 3
		Current OPR	-1.5	Avg Seed Score	1.2			Current OPR	3.9	Avg Seed Score	2.7		
				auto % handled	0%					auto % handled	77%		
		robot speed	2.1429	auto % scored	0%			robot speed	1.8182	auto % scored	29%		
		cross zone	1.1429	tele ball handle	1.5556			cross zone	1.1	tele ball handle	1.5		
				tele ball scored	1.1111					tele ball scored	0.3333		
		ball control	2.1429	finale ball handl	0			ball control	1.5455	finale ball handl	0.0833		
		avg ball handle	1.5556	finale ball score	0			avg ball handle	1.5833	finale ball score	0.0833		
				elevate/suspen	0					elevate/suspen	1		
		start zone	1.5556	# of penalties	0.1111			start zone	2.9167	# of penalties	0.25		
	Auton:				0		Auton:				0		
	Finale:				0		Finale:				0		

What are the Different Scouting Positions?

- Scouting mentor
- Head scout
- Pit scout
- Match scout
- Video scout
- Data analyst

Quick Tutorial in Matrices

In mathematics, a matrix (plural matrices) is a rectangular table of elements (or entries), which may be numbers or, more generally, any abstract quantities that can be added and multiplied. Matrices are commonly used to describe linear equations.



The horizontal lines in a matrix are called rows and the vertical lines are called columns. A matrix with m rows and n columns is called an m-by-n matrix (written m × n) and m and n are called its dimensions. The dimensions of a matrix are always given with the number of rows first, then the number of columns.

Quick Tutorial in Matrices

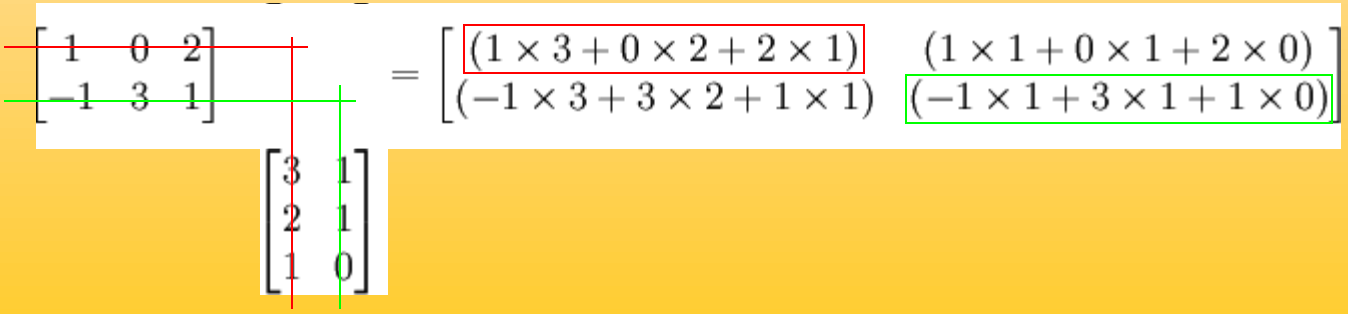
Matrix addition

$$\begin{bmatrix} 1 & 3 & 1 \\ 1 & 0 & 0 \\ 1 & 2 & 2 \end{bmatrix} + \begin{bmatrix} 0 & 0 & 5 \\ 7 & 5 & 0 \\ 2 & 1 & 1 \end{bmatrix} = \begin{bmatrix} 1+0 & 3+0 & 1+5 \\ 1+7 & 0+5 & 0+0 \\ 1+2 & 2+1 & 2+1 \end{bmatrix} = \begin{bmatrix} 1 & 3 & 6 \\ 8 & 5 & 0 \\ 3 & 3 & 3 \end{bmatrix}.$$

Matrix multiplication

$$\begin{bmatrix} 1 & 0 & 2 \\ -1 & 3 & 1 \end{bmatrix} \times \begin{bmatrix} 3 & 1 \\ 2 & 1 \\ 1 & 0 \end{bmatrix} = \begin{bmatrix} (1\times 3+0\times 2+2\times 1) & (1\times 1+0\times 1+2\times 0) \\ (-1\times 3+3\times 2+1\times 1) & (-1\times 1+3\times 1+1\times 0) \end{bmatrix} = \begin{bmatrix} 5 & 1 \\ 4 & 2 \end{bmatrix}.$$

2 x 3 3 x 2 2 x 2



Quick Tutorial in Matrices

The following is a system of equations with two equations and two unknowns.

$2x + 5y = 16$

$x + 3y = 9$

This can be rewritten in matrix form

$$\begin{bmatrix} 2 & 5 \\ 1 & 3 \end{bmatrix} \begin{Bmatrix} x \\ y \end{Bmatrix} = \begin{Bmatrix} 16 \\ 9 \end{Bmatrix}$$

$$\begin{Bmatrix} x \\ y \end{Bmatrix} = \begin{bmatrix} 3 & -5 \\ -1 & 2 \end{bmatrix} \begin{Bmatrix} 16 \\ 9 \end{Bmatrix}$$

$$= \begin{Bmatrix} 3 \\ 2 \end{Bmatrix}$$

Offensive Power Rating

From the Chief Delphi forum, the earliest I found the use of the term Offensive Power Rating (OPR) was by Scott Weingart ("sw293") in his April 2006 posting. I think he first coined this term OPR and explained how it is calculated in the Chief Delphi post:
http://www.chiefdelphi.com/forums/showpost.php?p=484220&postcount=19

Karthik Kanagasabapathy from Team 1114 did the same calculation and called it Calculated Contribution. He first published it in 2008.

"Bongle" from Team 2702 and Guy Davidson from Team 8 implemented the calculation of OPR from "sw293" and published a lot of results on Chief Delphi before the Championship in 2008.

How to Calculate OPR?

Assume team i, j and k are three teams in an alliance and they scored p points in that match. Then we can write

$$x_i + x_j + x_k = p$$, where x_i is the score contributed by team i

Assume team i played with team m and n in another alliance and they score q points in that match. Then we can write

$$x_i + x_m + x_n = q$$

If we add all the matches that team i was involved in, we get

$$2x_i + x_j + x_k + x_m + x_n = p+q = B_i$$

If we put them in row i of an N x N matrix A, where N is the total number of teams in that regional, and repeat that for each team, we get

How to Calculate OPR?

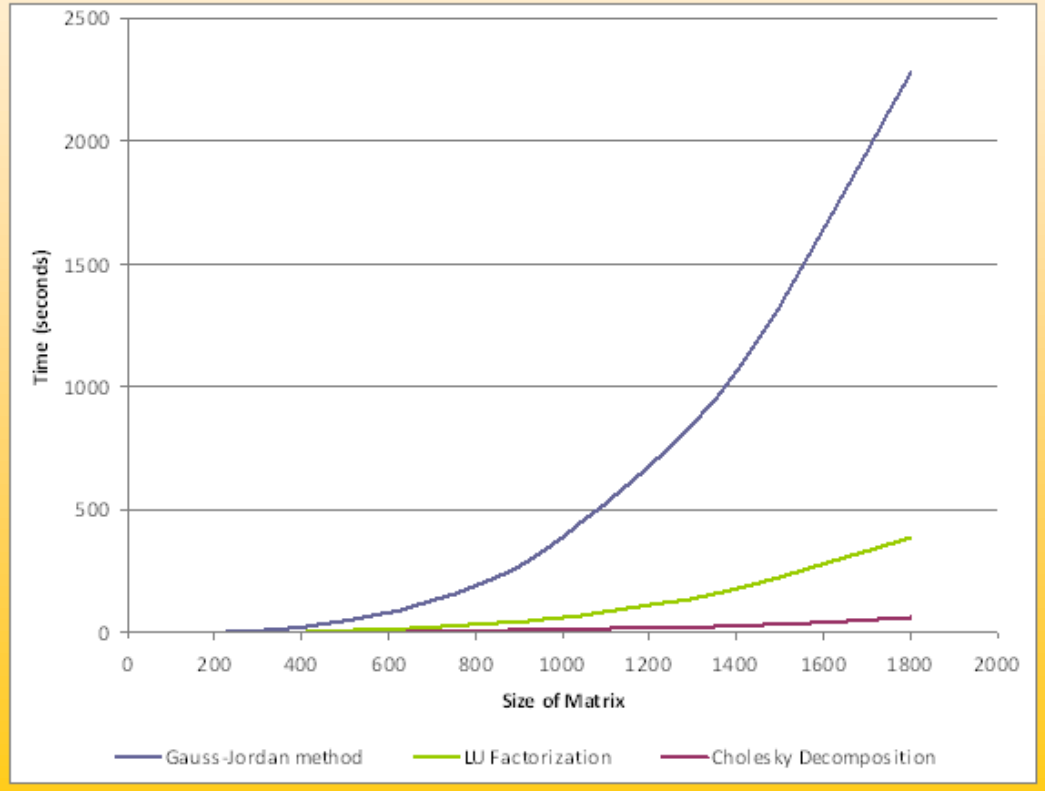
$$2x_i + x_j + x_k + x_m + x_n = p+q = B_i$$

$$\begin{array}{c} \\ i \\ j \\ k \\ l \\ m \\ n \end{array} \begin{array}{c} \begin{array}{cccccc} i & j & k & l & m & n \end{array} \\ \left[\begin{array}{cccccc} 2 & 1 & 1 & 0 & 1 & 1 \\ 1 & 1 & 1 & 0 & 0 & 0 \\ 1 & 1 & 1 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 \\ 1 & 0 & 0 & 0 & 1 & 1 \\ 1 & 0 & 0 & 0 & 1 & 1 \end{array}\right] \end{array} \left\{\begin{array}{c} x_i \\ x_j \\ x_k \\ x_l \\ x_m \\ x_n \end{array}\right\} = \left\{\begin{array}{c} B_i \\ B_j \\ B_k \\ B_l \\ B_m \\ B_n \end{array}\right\}$$

$$[\,A\,]\{\,x\,\} = \{\,B\,\}$$

How to Calculate OPR?

Since the matrix A is symmetric and positive definite, we can use Cholesky decomposition to solve for x. The result x is the contribution of each team to each of their alliance. The number is known as the Offensive Power Rating of each team.



A Proposed New Method

The drawback of the Offensive Power Rating is that it completely ignores the contribution of defense. Jay Lundy from Team 254 has proposed another method that takes into account both defense and offense. Please refer to Chief Delphi post
http://www.chiefdelphi.com/forums/showpost.php?p=733759&postcount=160

However it will result in a rectangular matrix which is harder to solve. Also the offense and defense numbers may be hard to interpret.

Hence I am proposing a new method that takes into account both offense and defense directly and still have a symmetric and positive definite matrix.

A Proposed New Method

Once you understand how to calculate OPR, it is fairly simple to calculate this new rating. It is based on the winning margin of each match rather than the points scored. So instead of adding up all the points of all the matches and put into B_i, you add up all the winning margins and put into B_i.

$$2x_i + x_j + x_k + x_m + x_n = p+q = B_i$$

I call this new rating CCWM which simply stands for Calculated Contribution to Winning Margin.

Notice that some teams have negative CCWM and if you add up all the CCWM of all the teams in the regional, you will get zero.

A Proposed New Method

This CCWM gives credit to teams that play good defense. In games where your team's Match Ranking Points is based on your opposing alliance's score, this should still be valid since you want to score as many points as possible. The only time it does not work is if your team is allowed to intentionally score points for your opponents' alliance. Even so, this does not occur very often unless there is a very big lead and you know you will win for sure. However in a two minutes game, after establishing a big lead, the amount of time left to intentionally score points for your opponent is limited.

Comparison between OPR and CCWM

Using 2008 Regional data, I found that CCWM is as good as OPR in terms of predicting the outcome of the elimination matches.

CCWM seems to correlate better than OPR in terms of actual teams selected as alliances even though there are many factors that affect how teams are selected.

For a game like the one in 2008 where there are only two balls to hurdle and the third team can either run laps to score points or play defense, the first pick should probably be one who can score as many points as possible. Hence OPR can be a good criteria. For the second pick, I think that using CCWM will have a better chance than using OPR to unearth a gem that is overlooked by other teams.

My conclusion is OPR and CCWM both have advantages and disadvantages. It depends on the game and how the match ranking points are scored.

A Note on DPR and PMR

At around the same time that I developed CCWM, other people have proposed calculating DPR which stands for Defensive Power Rating and PMR which stands for Plus/Minus Rating. These were proposed by a number of people but made popular by “Bongle”.

DPR is calculated similar to OPR except the vector B is the sum of all the opposing alliances’ scores instead of your alliances’ scores. PMR can be calculated by subtracting DPR from OPR.

Jesse Knight of Team 1885 was the first to notice that CCWM and PMR are numerically identical and he verified it with his program. Subsequently, I published a proof why they are numerically the same at
http://www.chiefdelphi.com/forums/showpost.php?p=835222&postcount=48

Hence DPR = OPR - CCWM

The Interpretation of OPR

OPR does not predict what a team (robot and human player) can score. It is the calculated contribution by that team on average to all the matches they were involved in to their alliance partners. A team that has high OPR score means that every time they are on the field, good things happen to that alliance meaning high score. Some of the possibilities are:

1) their robot score a lot of points
2) their human player score a lot of points (2009)
3) their presence allow their alliance partners to score a lot of points which they don't normally do as well.
4) they have on average stronger partners and weaker opponents by the luck of the draw than other teams.

A low OPR is just the opposite.

The Interpretation of CCWM

CCWM is the calculated contribution to the winning margins of the matches the team was involved in. A negative CCWM means the team is a liability to their partners. A team with negative CCWM should not be picked as alliance partners.

A team that has high CCWM means that every time they are on the field, good things happen to that alliance and in this case it means winning by a big margin. Some of the possibilities are:

1) they score more points on others than others score on them
2) their presence allow their alliance to score more points on others than others score on them. This could be from playing defense or help pin an opposing robot so their alliance partner can score more (2009)
3) they do not incur much penalties.
4) they have on average stronger partners and weaker opponents by the luck of the draw than other teams.

Features of Team 2834 Scouting Database

Questions?

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